DIY: How to Build a Solar Water Distiller

Do It Yourself - How to Purify Water Via a Non-Electric Solar Still at Home

Sharon Buydens

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By Sharon Buydens

Do It Yourself: How to Build a Solar Water Distiller

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DEDICATION

Dedicated to my oldest son Tyler for always being able and ready to help me install solar stills in the field in west TX, NM, and Mexico. So many times you have been there for me, to help me, including in the rehab real estate project in WA. Thank you. I love you son.

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AUTHOR BIOGRAPHY

Sharon Buydens

My background in solar energy projects really started when I was flipping through the yellow pages one late summer day in El Paso, Texas at age 19. I came across the ‘solar energy’ section and happened to see the *El Paso Solar Energy Association* (EPSEA) listed there.

To my excitement, EPSEA (epsea.org) had monthly meetings with special speakers on various topics at the time, which was free to attend at UTEP (University of Texas at El Paso). I suddenly had exposure to people who had built steam cars, or solar room heaters out of used materials, learned how to make solar ovens for cooking food, built solar water distillers, made designs of solar homes, and heard how others built homes out of alternative construction materials such as adobe, rammed earth, rock, cob, or even log homes.

I was speedily asked to become a volunteer and later to join as one of the members on the Board of Directors. By the following year I was voted in as Secretary and also wrote articles on solar topics as I learned about them. I was to stay in that Secretarial position for another two and a half

years before moving away to Nebraska to build my own passive solar home.

Because corn and wheat fields were abundant, I decided to build indigenously with local materials—a straw bale house. I joined SBAN (Straw Bale Association of Nebraska) and became the Library Committee member. I signed up for *The Last Straw* Journal (excellent resource out of Colorado at thelaststraw.org) and learned everything I could about how to build a house out of bales.

The house was passive solar in design, and utilized mostly used/recycled materials. We built a composting toilet, had a greywater system, and made earthtubes for natural passive cooling.

By 1999 we sold the house and moved back to El Paso, Texas. I rejoined the Board of Directors for EPSEA and in 2001 was voted in as Vice-President, newsletter editor, and by 2001 was both the EPSEA President and Project Manager for two bi-national mini-grants ($10,000 each) and a $100,000 EPA (Environmental Protection Agency) grant to install solar water distillers in local and rural unincorporated communities (subdivisions or neighborhoods called “colonias”) along the US-Mexico border, including west Texas, southern New Mexico, and Mexico.

By 2002 I dropped the fancy titles and sat on the Board of Directors before phasing out of my non-profit endeavors, opting for selling small e-books and booklets on how-to topics. I went back to school at UTEP (University of Texas at El Paso) in 2004 for cultural anthropology. I also worked on grant writing and as the Organizing Assistant for the non-profit organization, *Border Interfaith* (borderinterfaith.org) where my community surveys and associated report (the Canutillo Water Project) helped the local colonia get city water due to their contaminated shallow wells.

In 2008 I transferred my studies to Ashford University, and in 2010 I graduated with a BA in Social Science, with an Anthropology specialization, followed with a move to the greater Seattle, Washington area. I have found that solar energy, alternative construction, and natural living have phased in and out of my life, but always seems to come back.

In 2012 I compiled my six solar energy related e-books (how to make a solar distiller, solar oven, passive solar home design, intro to photovoltaic (PV) and wind energy, hurricane and tornado resistant homes, and

earthtubes for cooling) into one single book and published it on Amazon and Kindle.

In 2015 I decided that the book needed updating so I chose to separate each original topic out into different titles so people could find them easier; hence, this book is now a *DIY: How to Build a Solar Water Distiller*, and there will be separate ones on solar ovens, passive solar homes, and so on. I have added in many more pictures and textual information and edited it so that it reads easy. I hope you enjoy it!

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INTRODUCTION

By far the most popular topic I have ever written about has been that of the solar water distiller. Solar stills are in demand, I believe, because they represent the concept of PURE WATER to people, which is something that our society—even in developed nations—lack many times. City water is full of chlorine and sometimes fluoride (or other toxins) even though it is considered safer than in developing nations.

WATER IS LIFE, no doubt about it. Without water we feel quickly fatigued, and it even affects our ability to concentrate, and if dehydrated severely can cause health problems, including with our kidneys and other organ functions.

I am amazed at how many people in America do not drink water—*any* water—and only consume carbonated beverages, artificially flavored drinks, coffee, black tea, cow's milk that is full of hormones and other nasties, energy drinks or other sweetened drinks, when water is not only free or inexpensive (unless you buy it bottled), but FAR better for our bodies and health. We are a nation full of diabetics and cancer-ridden people, in part, because of toxins in our environment and food supply, but also our water, lest we not overlook that fact.

I happen to love water, and having come from the desert growing up—where water tastes saline and is full of hard minerals—I can say that having a distiller on hand, which can produce FREE purified water *without the need for filters or pumps or electricity*, sure comes in handy. This makes the initial cost, in comparison to those ongoing expenses with other purification systems, basically pay for itself in a relatively short period of time. It only costs a few hundred dollars (or less in some cases) to build a solar still, or several hundred if you wish to purchase a professionally made distiller, but over the coming years having one will pay for itself likely several times over.

So is it about health for you? Or is it about saving money? Or could it be that where you live has little to no potable water? Maybe your water just tastes or looks or smells bad? Perhaps there is a medical purpose that you need to attend to? There could be a million other reasons to build a

solar water distiller, and I will cover many of the problems and the solutions (a solar distiller of one kind or another) here in this book.

I do hope you enjoy my story and can find value in my experiences designing, building, teaching, and using solar distillers, and please check my website for updates on free ebooks on other solar energy and miscellaneous topics at: www.sunstar-solutions.com

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SOLAR DISTILLER BASICS

The first question usually posed to me is, “What is a solar distiller?” or, “What is a solar still?” (note that I will use the words “distiller” and “still” interchangeably throughout this book) or, “How does it work?” or even, “Where do I place it?” I will answer these questions next…

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What is a Solar Distiller/Still?

A solar water distiller or “solar still” is basically a simple, waterproof, insulated “box” with a piece of glass on top that uses the sun’s energy to purify water through the process of evaporation and condensation —just like how rain is made (the hydrologic cycle). You then collect the condensate and use it for cooking or drinking or other purposes.

That is the simple version, but you will see as we move forward in this book that although this is a simple process, it is also a very powerful process because it not only completely decontaminates/purifies bad water, but it also does so without the use of electricity or the need for city water (meaning water pressure).

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How Does it Work?

To use a solar distiller your source water is placed inside, then the sun's rays heats the water and distills it passively. Solar water distillation that is "passive" means it has no moving parts, and uses no electricity whatsoever.

The purified or distilled water (called "product water") is then rendered safe for drinking and cooking, with absolutely no contaminants that are found in regular (potable or non-potable) water.

Raw sewage has been placed into these distillers as a test, yet pure and absolutely clean water is distilled as the final product (yes, confirmed by tests at a laboratory). Sound gross? It may, but it works! Bacteria and microorganisms simply cannot survive the distillation process, and everything (solids, chlorine, etc.) in the water is all left behind.

"Pure" water is the most clean water you can find on the planet, which means it is devoid of all contaminants, whether particulate or solid, microbial (bacteria or microorganisms or virus), or chemical. The only known exception are volatiles (like kerosene or gasoline), which can survive the distillation/evaporation-condensation process because, like distilled water, they are distillates also. I explain later how to deal with this issue easily, however.

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Solar Distiller Plans

You may want or need construction plans to make a single basin still (cost usually runs between $200 - $350). Originally the full construction plans were available through the non-profit organization, the ***El Paso Solar Energy Association (EPSEA)*** website at: www.epsea.org, but unfortunately their purchase page is no longer available as of this writing since EPSEA has been defunked for several years. I was their President in 2001, and had served on the Board of Directors for many years, during two different periods. I was saddened to see it die since it had held the title of the "longest running solar association in the United States."

Homemade "EPSEA" style solar water distiller

Since the non-active status of EPSEA has been the case for many years I have synthesized the full still construction plans (separate from this book), which are available through my website www.sunstar-solutions.com or through Amazon under the title "Solar Water Distiller Construction Plans" ($27 USD) but will not be fully represented here in this book.

I will, however, tell you much of what you need to know to grasp the basics and methods of making a solar still; and yes, you can build your own still with the knowledge you glean from this book, without the construction plans, although some people need or prefer step-by-step instructions, which

is why I made it available separately. They are not necessary if you are handy with simple tools and have a logical mind for projects of this nature or scope.

Read to the end of this book before deciding whether you feel it is worth the effort in making this still versus buying one, or whether you think you need step-by-step plans or not.

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Where do I Place it?

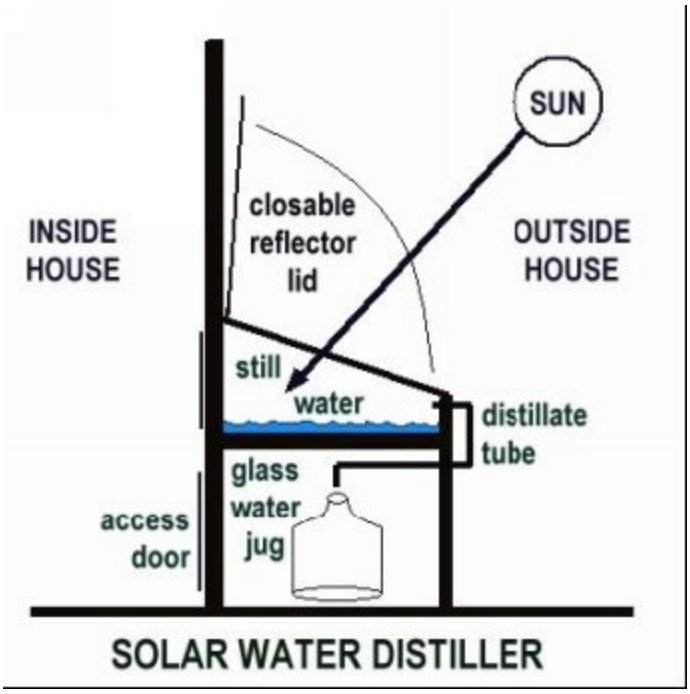
The short answer to this is “south.” But really, you will need to face the solar still to “solar south,” which is slightly off from magnetic south. I will explain in the next section, so for now just think “south” from your house or location.

This southerly-facing direction to aim the slanted glass portion of your still is for the northern hemisphere, of course. For the southern hemisphere the sun will actually be shining in the northern latitudes, so you will want to face your still to the north for optimum solar gain.

Since I am in North America, I am writing this book as if one is living in the northern hemisphere, so please just make adjustments as necessary.

You can install a still permanently to the side that has southern exposure or south-facing sunlight side of your house, and access the distillate from within the house. Be careful of overflows… you may wish to put in a floor drain or other method to deal with unattended distillate if you have distillate flowing into your house or building from the outside. If your still is high enough you can also simply put any overflow to go down your sink. I have installed stills on roofs that used this method for collection without the risk of overflow.

Alternatively, instead of having the product water flow into a glass jug or other container, you can collect it in a cistern or other non-plastic heat-resistant potable-water-safe container of a much larger size than just a few gallons. Below is a picture of a still attached to the solar-facing side of the house.



Most people build a portable still and keep it in their yard, but some people do not prefer to walk outside to check on the water or to retrieve it. If that is the case then there are other options, and really, it is up to you.

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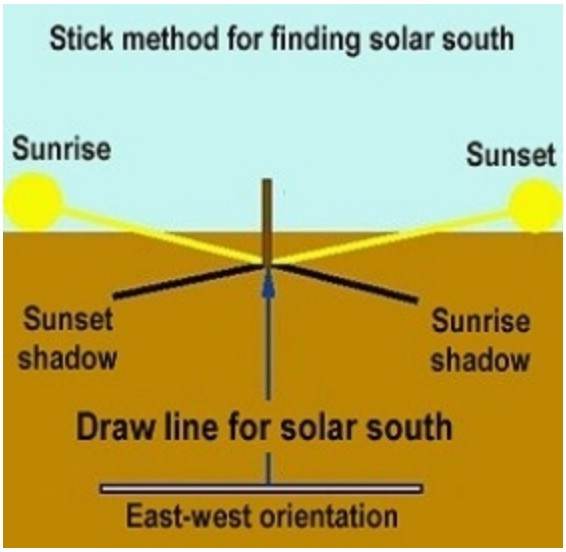
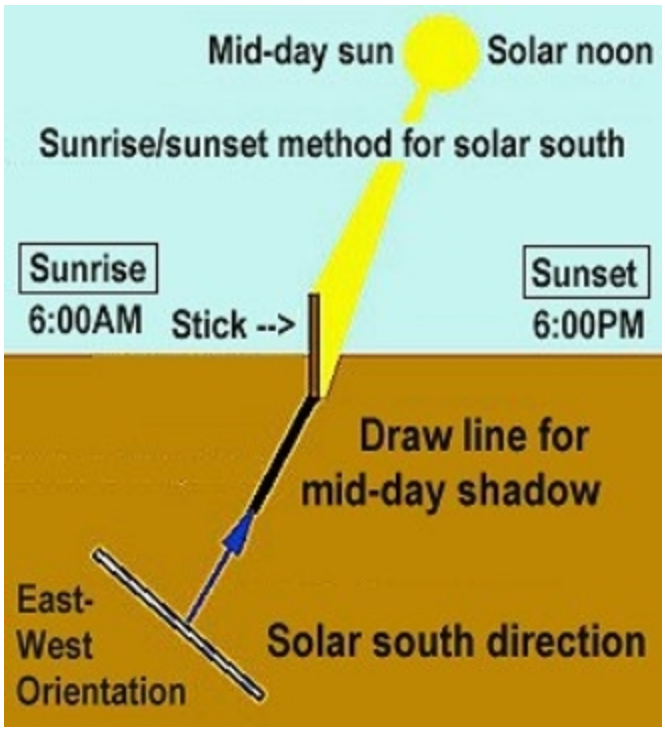
Finding Solar South

How do you find solar south? It is actually pretty easy, and there are a few different methods, which I will cover here. This information is borrowed from my book on how to design a passive solar house:

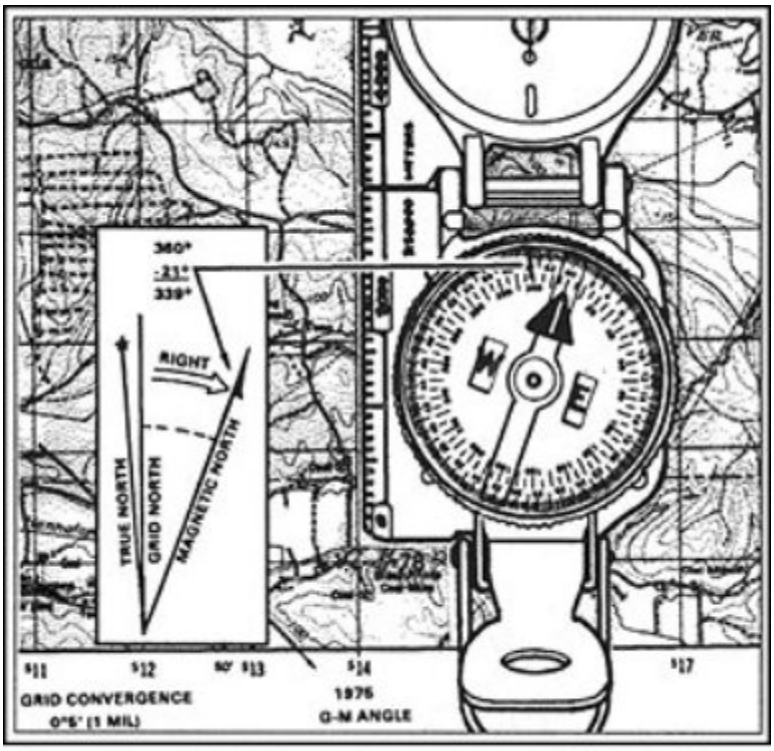
1. **Place a stick straight up in the ground and draw a line on the shadow cast at sunrise. Then draw another line on the shadow cast at sunset. Directly in between the two shadow lines draw a third line (on the south side). This indicates the direction that the sun will be coming from exactly in the middle of the day (any time of the year). This should be south-southeast for most areas of the U.S.**



2. **Watch the news on television, or check your Almanac and note the times of sunrise and sunset. At exactly in between these two times, called "solar noon," place a stick straight up in the ground and draw a line where the shadow is cast. Facing towards south (where the sun is) is where the line should point. This is solar south.**



3. **Find your location and see what the <u>compass</u> deviation (or angle of magnetic declination) is by looking on a <u>topographical map</u>.**



Source: http://www.globalsecurity.org/military/library/policy/army/fm/3-25-26/image139.gif

Compass deviation
Picture source: www.globalsecurity.org

Example #1:

For Lincoln, NE solar south is nine degrees *east* of magnetic south according to the deviation. The main solar heating hours for the Lincoln area are between 8:00AM and 2:00PM each day. Since so many of the hours to receive direct gain are in the morning hours, many people choose to face their glass this extra nine degrees to the east side of south. But beware; anything facing more than 40 degrees off solar south (either way) starts to lose efficiency at a rapid rate.

Example #2:

Another example is for El Paso, TX where solar south is 12 degrees *east* of magnetic south according to the deviation. The main solar heating hours for the El Paso area are between 9:00AM and 3:00PM each day.

Now that you know where to place your still and which way to face it, I will move on to the nitty gritty of how solar distillers really work.

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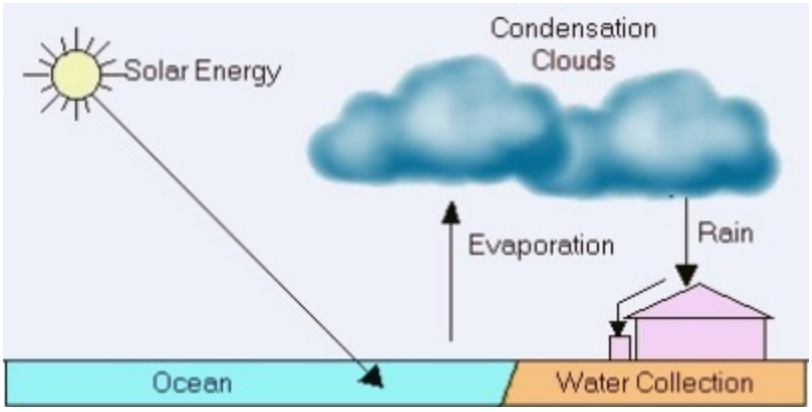
HOW SOLAR STILLS WORK

Solar stills are basically just like making rain. In nature, the sun (solar energy) shines and heats the air and water (from the ocean and lakes, etc.) and causes the water to *evaporate* into the air as water vapor. Warm air can hold more vapor than can cool air. As it cools down it *condenses* and forms into microscopic particles that become visible as clouds in the sky, then when the conditions are right it finally falls as rain, or precipitation.

You can catch this water in a container to use for plants or other purposes. It is well known that rain water is the most pure water on the planet (unless it has been contaminated by pollution in the air from cities and factories). Plants LOVE rain water and thrive on it. Our bodies do too.

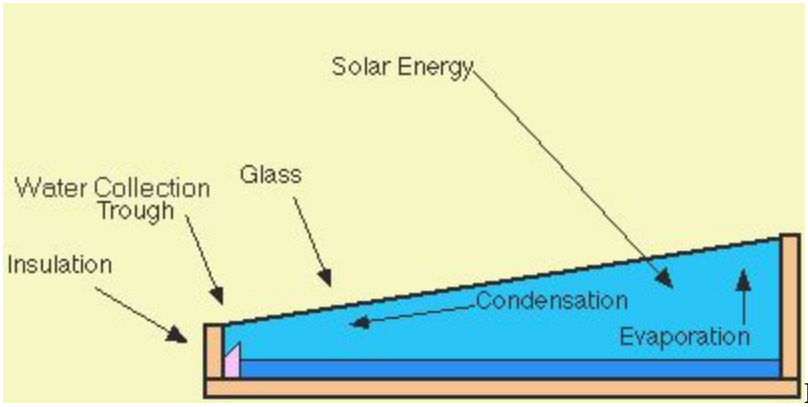


How rain is made and used:
Evaporation, Condensation, and Collection

A solar still, or distiller, makes pure water the same way rain is made. The sun's energy shines and heats the air and the water inside the still causing the water to *evaporate* inside the still, and then *condenses* on the cooler glass above (the glass acts like a cloud). The water then drains down into a water-catching trough and out to a container.

This distilled water, or product water, can then be used for cooking and drinking or even bathing (some medical patients require pure water for

cleaning wounds or due to other health problems).



How solar distilled water is made and used:
Evaporation, Condensation, and Collection

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How Good is the Water?

The water that is made in these stills is of superior quality than bottled water because it is purified using the distillation process. Distilled water is some of the cleanest, most pure water you can get on the planet. Why? Because there is nothing left in the water once distilled… it removes pretty much everything!

Additionally, because the water is slowly evaporated, instead of rapidly boiled, the water tastes sweeter due to the natural process, and is around a neutral pH (vs. "forced distillation" done by boiling the water, which tastes flat and metallic, and tends to be acidic).

When you buy bottled water you often get that “plastic” taste, and who said that the water that has been sitting in standard plastic jugs—after having absorbed some of the smells and potentially carcinogenic toxins/dioxins from the synthetic container it sits in—is still good for you?

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Storing Distilled Water

The best storage container is by far a glass container. Stainless steel, although more expensive, is also good since you do not have to worry about the glass freezing and breaking in the wintertime, but make sure that it is high quality stainless steel because distilled water is so pure that it absorbs whatever it touches, and so can pit stainless steel over time.

This is why glass holding containers are recommended even though it is heavier and more fragile. Either way, the distilled water you get and store will be some of the best tasting water you will ever drink!

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Beware of Bottled Water

Bottled water stored in plastic is iffy; for instance, distilled bottled water again has the plastic taste because distilled water absorbs the qualities of whatever container it is in, including toxins given off by the container.

Considering the continent-sized “island” of plastic that developed and circulated in the Pacific ocean for years before anyone really publicized it, people have since been made aware and are getting away from using as much plastic, many even abstaining from using any plastic products whatsoever, like many people did with Styrofoam in the 1990’s. There are still a lot of people who do not believe that these materials are necessarily healthy to use, at least not long term.

Distilled water is PURE H2O and does not even have minerals so it potentially sucks up anything from its surroundings like a sponge. There is no evidence at all that it sucks nutritional content from out of your body, however. I have drank distilled water for decades without problem, as have my parents (they are in their upper 70’s now and in good health).

One interesting feature to note though, I have heard that drinking nothing but distilled water can cause electrolysis in your body, which makes you lose body hair over time, but interestingly, aging can cause the same thing, so I have some doubts in that hypothesis. Rain is also distilled water and no one I have ever heard of who drinks rainwater complains about losing hair either.

TIP: If your distilled water tastes flat because it has been sitting in a storage bottle, then to make distilled water taste fresh again is to shake it up to oxygenate it, just before drinking it, just like when raindrops pick up oxygen as they fall through the sky, which is what gives rainwater its amazing essence of life.

If you buy bottled distilled water also be aware of any possible pH issues (depending on how long it has been sitting on the shelves). I have personally drank boiled-distilled water from the stores that gave me heartburn due to the acid pH, so if I MUST have bottled water I stay away from distilled water from grocery stores and choose spring water instead

because at least it has minerals and a more neural pH. Minerals can also be added back into your distilled water, if you so choose.

Also, beware, spring water you buy in jugs may also only be well water, and it may be treated in different ways, depending on the brand. If you get store-bought water that has the label “Drinking water” realize it may only be standard TAP WATER! That title only means it is legally fit for drinking, but not that it is purified in any way. It may even have chlorine in it.

I will not even go into the astronomical prices per ounce or liter of bottled water, let alone the potential environmental damage they cause (outside of the plastic island I mentioned earlier).

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The Superior Solar Still

Regarding tap water, it is important to know that with potentially unhealthy additives like chlorine, fluoride, possible chemical and medical prescription drug pollutants, and other toxic substances in our in our sewers, water treatment plants/public water systems and environment, there are a good many reasons why you may want to distill your drinking and cooking water in your own backyard.

If you live rurally or go camping this is yet another reason to own a solar distiller. You can take river water, or lake water, or even water out of a muddy rain puddle, and distill it so that it is transformed into entirely pure H2O fit for drinking.

"Purified water" means it has been run through some type of filtration or similar purification process (possibly including ultraviolet/UV light), but this does not always take out all toxins.

"Reverse Osmosis water" (known as RO water) is about as close to distilled water as you can get; however, it takes two gallons of water to make every one gallon of RO water. This means that for every 100 gallons of purified that another 100 gallons of "muck" (dirty waste) water has been drained away into the sewers as waste. This is an incredibly inefficient way to produce pure water! Very wasteful indeed, not to mention *expensive* because in RO systems there are specialized costly filters to replace, not including the expensive equipment, plus maintenance on the machine, and the people to pay to take care of it.

Solar distilled water, in contrast to RO, uses one gallon of water to make one gallon of distillate (basically no waste), on average.

Advantages and benefits of solar water distillers include:

no filters needed
no pumps required
no fans necessary
no moving parts to break down
no electricity needed to run
passive solar in design (utilizes free energy)

portable or permanent
made out of new or recycled materials
water tastes better than forced-distilled (boiled) water
neutral pH
removes ALL contaminants*
lasts 20+ years (if designed right)
works anywhere that the sun shines (versatile)
good for urban or rural areas
excellent after earthquakes or natural disasters
saves money
eco-friendly (no carbon emitted to use)
small applications (individuals or family-sized)
medium applications (business or small community-sized)
large applications (commercial-industrial, cities, military)

*except volatiles, which are removed by a small carbon filter

Solar distillation removes contaminants such as:

salts
chlorine taste and odor
heavy metals (like lead or mercury)
bacteria (E. coli, and fecal coliform (causes cholera), etc.)
microorganisms (giardia, cryptosporidium, etc.)
sediments
sand
debris
rust/iron
minerals
fluoride
arsenic
other particulates or toxins

Yes, some minerals are good for you, as long as it is not like water where I have lived in the desert, which is too saline and has far too much calcium and hard minerals that clog showerheads, lead to buildup on your faucets and fixtures and shower walls/tub, and can affect health negatively

over time (such as causing kidney stones). Minerals and the rest of these contaminants named above, and more, are all *100% completely removed* through the distillation process. You can also get minerals through your food, and through supplementation.

If you accidentally put in water that is contaminated with volatiles (gasoline, kerosene, etc.) then a simple carbon filter from the local hardware store can be placed on the still, rendering the water safe to drink.

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WHERE STILLS ARE USED

Solar stills are appropriate technology for any geographical areas that have at least 5-6 hours of peak sunlight per day. They will not work as well in areas with less solar peak hours than that, such as extreme northern or southern latitudes.

Solar distillers also will not work very well on cloudy days or in areas that have a lot of rain. However, on sunny days they continue to work again.

You can use distillers at your home, at a cabin or your favorite camping spot, in border Colonias (unincorporated communities within 150 miles of the US-Mexico border) or other rural areas, in the city, survival situations, in the mission field, on a remote island, in the desert, and so on.

Stills come in different sizes. A smaller 2'x4' or 3'x3' sized (on average) still will produce approximately 1 1/2+ gallons (5 or so liters) of pure water per day in the summertime and about half that in wintertime.

The least expensive professionally manufactured still on the market that I know of is the **RAINMAKER™ 550** (which I will go into more towards the end of this book) and will typically produce most or all the cooking and drinking needs of 1-2 people (2 small stills, or 1 homemade larger (3'x6') still is usually enough for families). I know quite a bit about these stills because I used to install them in colonias in west Texas, southern New Mexico, and Mexico.

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EPSEA Solar Still Projects

In the late 1990's and also in 2000-2002, The El Paso Solar Energy Association (EPSEA) had two $10,000 grants from BorderPACT/CONAHEC for bi-national solar still installations, plus a $100,000 grant from the Environmental Protection Agency (EPA). These monies were used to install over 100 solar stills in west Texas and southern New Mexico in areas that are challenged with water problems, specifically in rural border areas called colonias (meaning "colonies" or "settlements").

I was the Project Manager for those solar distillation projects, so I worked with EPSEA and collaborated with community leaders to target colonia families in need, especially the elderly and the sick, or those with children or who were either financially in need or lived in areas with known water problems.

This banner was hanging at the community center in a west Texas colonia and says things like "Yes for regionalization," "Water for the colonias," "Equal representation," or "Water for 100 years"

Peaceful march for water representation and rights for colonias by colonia residents and supporters

My assistant Andrea Tirres explaining how stills work in Spanish

Besides health problems or lacking city water, people who received stills through these EPSEA solar still grant projects also may have lived in areas like Columbus, NM where unsafe levels of fluoride (naturally occurring, but over twice the safe national average) and high amounts of arsenic (from mine tailings in the area, which leached into the soil) were in the groundwater and city water supply.

Although an RO system was provided by Columbus to its residents, people had to go and fill up jugs, which was not always convenient, especially if residents did not have a vehicle or were ill.

Sharon Buydens (formerly Eby-Martin) with still recipient “David” in front of his fidobe (adobe and paper-cement (papercrete) mixed block) house in NM

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Colonias and Developing Nations

Colonias are unincorporated communities within 150 miles of the U.S.-Mexico border that lack infrastructure—meaning no city water or sewers, although they do often have well water and septic tanks. Some areas—such as the one in the picture above—actually did have city water, but their water supply, although treated, still had other contaminants not removed by chlorine alone, so a solar still was their best option for on-site potable water.

Many of these rural areas/colonias, like other developing nations (what used to be referred to as “third world countries”) are plagued with poverty and poor health conditions, although in the US even ranchers, farmers, and people of wealth also choose to live in these rural communities because of numerous reasons, including that being their livelihood. So contrary to popular belief, not all colonia dwellers are poor, not all live in sub-standard housing conditions, and not all have unsafe water sources. However, many do.

My assistant DD Levine with still recipient in Mexico

Some of the diseases lurking in the poorer colonias may include hepatitis, cholera, and tuberculosis, but only in some areas, depending on the particular colonia and their unique situation—based on geography,

geology, topography, political and social/cultural influences, access to medical care, economic opportunities (or the lack of it), etc.

Colonia in Juarez, Mexico - Note the large water tank in the background (obviously lacking city water is not the problem here)

Some of the homes in the colonias of Mexico are made out of pallets and cardboard and even dried mud or adobe blocks, or whatever cinder blocks or other materials they can get a hold of cheaply or for free. I have sat in some of these homes, eaten the food they offered, but selectively did not drink their water (they would offer boiled drinks like tea or coffee, however, or pre-bottled drinks, which I consumed).

I have spent plenty of time in Mexico and know the risks of drinking the water, eating the salad, having ice in your glass, or other rules that you know not to break. Nice restaurants serve bottled water, and even my dentist growing up was in Mexico, so I was familiar with the conditions of the city as well as the colonias when I began installing water distillers there.

Water faucet at the community center in Horizon City (east of El Paso), Texas where colonia residents can fill their water jugs free of charge.

You can see water draining from the sidewalk into the dirt from the faucet.

Vipin Gupta (right) handling blanket to keep still covered so it doesn’t “run” while empty

55-gallon drums in west Texas colonia, used for all household purposes including cooking and drinking

The time and place where a problem with water comes in—regarding colonias on either side of the border—is when some or all of their water is either held in tanks, pilas (homemade cement block tanks), or other containers like used 55-gallon drums. Some of these may be contaminated, yet this is the water that these families drink and cook with on a daily basis.

As Project Manager I met with leaders within the communities to help locate families in need. One of these areas included where some Catholic nuns ran an orphanage in Ciudad Juarez not far from the mountain. The old dump had been covered up, and people squatted and built their little homes of mud and pallets there. These were some of our first still recipients in Mexico.

Happy solar distiller recipient in Juarez, Mexico -BorderPACT grant funded EPSEA solar still project

Sharon (left of taller lady in middle) giving presentation on solar distillers to colonia residents at an orphanage that was run by nuns in Juarez, Mexico

Filling water bucket to gravity fill the solar distiller

Solar distiller “team” with grant project collaborators/funders (left to right): Unknown, Mike Cormier (EPSEA), Unknown, Vipin Gupta (Sandia Labs), Sharon (self), Robert Foster (NMSU), Unknown

Water purification message on a building in Palomas, Mexico

In the U.S. the colonias tend to be populated with mobile homes or simple (often uninsulated) concrete block or even adobe homes; but again, there are also exceptions depending on local and regional circumstances. Water problems and solar distillers seem to be made for each other, and a still is a viable solution in times of need.

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IS CITY WATER SAFE?

Is your water safe? Do yourself a favor and do an Internet Google search for “boil water advisory” along with the name of your state. Do the same thing with your state and words like: E-coli, fecal coliform, giardia, or others. City water service I have paid for has had small pieces of black particles, and even tiny pebbles and sand and other debris come through the pipes of this “clean” city water. Imagine the things that are in there that you cannot see!

Even if you ignore the issues with places labelled as colonias, some say that the industrialized, developed nation of America has the cleanest water in the world! Yet we find all over the U.S. (not just in colonias) private wells are contaminated with bacteria, E-coli, lead, arsenic, pharmaceutical residues, or other toxic substances, some of which are removable with the use of chlorine, and many that are not. Environmental pollutants and chemicals from agribusiness and factory or manufacturing sources is a continual issue in many cities. Cities, in fact, can be more polluted than many rural areas with private wells.

City water is not necessarily “good for you,” is it? Do Americans believe that chlorine is even healthy? You might want to think about getting a chlorine-removing filter for your shower so you do not breathe in the chlorine gas that is dispersed during a hot shower, especially if you have respiratory illness or other health issues.

The chlorine in America’s water supply is similar to antibiotics, which is a product that *does not distinguish* between killing off living BAD organisms (bacteria, microorganisms) and killing off living GOOD organisms (necessary bacteria in the human body). Yet we are still told that it is perfectly fine to consume this potential poison… to ingest it long-term and that it is actually “safe.” Do yourself a favor and distill your own water, live healthy, and ignore what the mass media tells you to believe. Here are some facts about city water you might want to know about…

• **A study by the California Department of Health** found that pregnant women consuming five or more glasses of municipal water had a 15.7% increased incidence of miscarriage. Doctors are saying drink eight glasses of water a day! *Source: Epidemiology report findings mentioned in the San Jose Mercury News, Los Angeles Times, and The Metro newspapers (Feb 1998) AND Pubmed (Savitz, Andrews, et al.):*
http://www.ncbi.nlm.nih.gov/pubmed/7556013

Too obscure? Perhaps it is outdated, or other variables were not considered since no studies with similar results have been done since then that I could find. Consider this…

Fluoride is another issue. Fluoride is an ingredient in toothpaste because it is said to help fight cavities, so does that necessarily mean that it is "safe" to be ingesting on a daily basis? I have known children who eat unsafe quantities of toothpaste regularly even though they are supposed to use a pea-sized amount and spit it out (they swallow instead).

Municipal water that contains fluoride has been accepted and also avoided in certain areas of the country because of this debate. The use of fluoride in water has been stopped, rejected, or banned/outlawed completely in many—if not most—industrialized and developed nations including: Austria, Belgium, China, Denmark, Finland, Germany, Hungary, Japan, Norway, Sweden, and The Netherlands, among others; America is behind the times.
Source: www.fluoridation.com/c-country.htm

The "safe" (highest acceptable - standards set in the U.S. by the Environmental Protection Agency (EPA)) level for ingesting fluoride is considered to be a count of **maximum concentration limit of 4 mg/L** in water tests. **Enamel fluorosis can occur when children are chronically exposed to fluoride at concentrations of 2 mg/L** or higher.

Children with fluorosis (fluoride poisoning) have bone strength problems (since fluoride actually leaches calcium from the bones/teeth, making them weaker, not stronger), developmental problems, health problems, and white spots on their teeth (mottled) and skin due to the unnecessarily high levels of natural fluoride found in the water table.

Children and adults who have had this problem were, amazingly, found only a 45-minute drive away from Deming, NM, where their (Deming's) claim is to have some of the cleanest and "best" water in the state! Due to geological reasons and old mines in the mountains, the village of Columbus, NM has high arsenic counts in their water. Plus Columbus has (found naturally) at least 200% higher than the maximum limit of fluoride concentrations (over 8 mg/L based on tests from 2001) in their groundwater.

Water Festival held in Columbus, NM

Greg Vogel and Mike Cormier carrying an EPSEA distiller for display at the Water Festival

The village, as I mentioned before, put in an expensive RO system for residents to fill up their bottles for drinking/cooking, but some of the residents, thanks to the EPSEA solar water distillation project, have solar stills at their homes so they do not have to travel to the town square to fill up their bottles with clean water and haul them back every time… they distill it on-site instead, which is far more convenient. Their solar stills remove ALL the fluoride and arsenic, as well as chlorine from the city water, thereby removing the danger of ingesting any of it unnecessarily.

The best reasons for having a solar still are not always just the practicality of on-site water purification but the reasons behind what drives us to want purified water in the first place…. our HEALTH is a big issue in our toxin-filled society today.

Next I will cover solar water purification for bacteria and microorganisms when there is no solar still available, then I will go into how to make a solar still.

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SOLAR WATER DISINFECTION

Note that this next method, unlike distillation, does not remove volatiles or sediments/solids, minerals or other contaminates, but it will kill the bacteria and microorganisms found in river and lake water, contaminated city water sources after an earthquake or other disaster, and other similar scenarios. No book on solar water purification would be complete without this knowledge being presented.

Recently, when I went through my belongings that had been in storage the last five years, I came across an original paper handout that we at EPSEA used to give away to people about solar stills (back when I was still on their Board of Directors). This information has always been given away freely to the public, so I am happy to share it with you here so it is not lost in the annals of time. This is something that anyone can do, anywhere in the world, as long as there is direct sunlight.

"WATER PURIFICATION
USING DIRECT SUNLIGHT

> "The earthquake in San Francisco certainly made us more aware of the harsh situations that could develop during a time of disaster. One of these, and a most vital one, is the lack of good drinking water. The Energy Information Center in El Paso kindly gave us a simple method of water purification for drinking which we would like to share with you.
>
> "Because the results have such unlimited potential for disease prevention throughout the world, during the first half of the International Water Supply and Sanitation Decade (1981-90), five major institutions carried out extensive research projects to

determine the role of violet and infra-red radiation in the disinfection of drinking water.

“The testing involved subjecting 1 to 3 litre capacity containers of contaminated water to direct sunlight for varying periods. Water samples were deliberately contaminated with municipal sewage to high levels not normally encountered even in rural areas where drinking water is untreated. They found that 99.9% of coliform bacteria were killed in 95 minutes.

“The time required to destroy 99.9% of the coliform bacteria by exposure to sunlight ranged from 70 minutes for colorless polyethylene bags to 1050 minutes (17.5 hours) for dark brown bottles. The mean value for all types of colorless glass or plastic containers was found to be 85 minutes. Colorless glass or plastic containers are the best choice whenever available.

“Storage for five days of disinfected water showed that the inactivated coliform bacteria failed to regrow at ordinary room conditions. To avoid recontaminations it is preferable that the water be kept in the same solar-sterilized container. To make it more acceptable for drinking, let it cool overnight as the water gets warm during sterilization.

“Dishes and similar tableware can be effectively decontaminated by exposure to sunlight for as short a time as 15-30 minutes. Containers should be properly spaced to avoid shadows.

“During cloudy days, all that is necessary would be to prolong the exposure period from a minimum of one hour to several hours. The routine procedure from morning to afternoon would be more than adequate even on days with reasonable cloud coverage.

“The project’s overall findings are that in both summer and winter, the household water supply can be disinfected on a

> routine basis if clean transparent containers are put in the sun in the morning and exposed until late afternoon. Shading of the containers must be avoided, and turbid waters must be filtered or left to settle.
>
> "This is a simple, practically costless method of disinfection which could be adopted by the vast majority of people in the world.
>
> "Note: This information was taken from the text of a UNICEF manual." - end

Note that this method of solar water purification/disinfection is also referred to as *solar water pasteurization*.

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Solar Ovens for Solar Water Pasteurization

In colonias as well as many developing countries solar ovens/cookers are not only used to help pasteurize water in this same way, but also solar cookers replace expensive gas/propane/butane, electric (if available) for cooking, or the need to scrounge for firewood so they can cook their food.

A solar oven can be made from simple materials like recycled cardboard, aluminum foil, and school glue, then topped with a piece of glass (some people have utilized an old car window or Plexiglas).

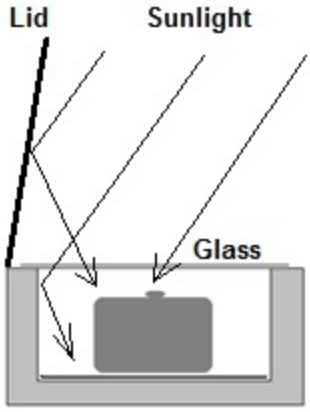
Anything you can cook in a regular oven, Dutch oven, or slow cooker (crock pot) you can cook in a solar cooker.

There are numerous types of solar ovens, which I go into in my book:

"DIY: How to Make a Solar Oven"

Available at Amazon.com or my website:

www.sunstar-solutions.com



Solar oven used for solar water pasteurization

As you have seen already, you do not really need a solar oven to solar pasteurize water, but if you are in an area where the quality of the water is seriously in doubt and microorganisms and/or fecal coliform bacteria (found in raw sewage) might be present, then you may be able to

pasteurize your water just by placing it into a solar oven rather than just sitting the jug or glass jar in the sun; this is an alternative to boiling water.

Except for acid rain (or any rain contaminated by volcanic ash, etc.), rainwater is likely the most pure water you can collect outside of a known pristine source—even mountain springs can be contaminated with bacteria or microorganisms.

If there is no rainwater to collect from the sky, then you can wait until the muddy water in a puddle settles and carefully skim the clearer water off the top of it into your container. Once your jar or jug has the contaminated water in it, then place it in direct sunlight. This can also be water from a stream or river or lake or pond if you are camping or lost in the woods.

If using a solar oven, set the CLEAR container in the (preferably preheated) solar cooker in full sun. Make sure the water is not shaded or too cloudy as the Ultraviolet (UV) in the sunlight will kill off 99.9% of all bacteria and micro-organisms within 90 minutes (in FULL sunlight, otherwise leave it up to a few hours), plus once the temperature reaches 131 to 149 degrees F(55-65 ◦C), then anything else left behind will automatically be killed off within a short time.

This process of solar pasteurizing water works great for contaminated water that has fecal coliform bacteria (a main cause of cholera and diarrhea in developing countries) or that has microorganisms such as giardia (commonly found in water) or cryptosporidium (often found in lakes or ponds).

Temperatures needed to pasteurize for these:
Microorganisms: 131°F (55°C) – Worms or protozoa cysts (cryptosporidium, entamoeba, giardia) **Bacteria: 140°F (60°C)** – V. cholerae (or fecal coliform), E. coli, shigella, Salmonella typhi,

rotavirus

Virus: 149°F (65°C) – Hepatitis A virus

It is important to note, just to caution you again, that pasteurization of water does NOT remove solids such as sand, sediment, rust, nor does it remove minerals, arsenic, fluoride, chlorine, volatiles (like gasoline, kerosene, pesticides/herbicides), chemicals, or heavy metals. You would need to build a solar water distiller for that.

So that brings me to the next topic…

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MATERIALS & TIPS

The great thing about solar stills is that you can “make your own rain” via evaporation and condensation within the still on any sunny day. Stills can be bought from companies (such as www.SolAqua.com, which is where we got some of our solar distillers for the EPSEA grant community projects) or you can build the still yourself using a variety of materials available to you.

Basically, there are three ways to make stills. The cheap way, the better way, and the best way, each with their own respective price tags.

If none of those options appeal to you there is always the option of buying one commercially made. Depending on whether or not you have some of the materials on-hand, just lying around your house or gotten free or cheap from a neighbor or friend, weighing out these factors may best determine if your still is going to wind up being less expensive or more expensive than purchasing a new one.

Typically larger stills can be made for $350 or so. The process can be a bit time consuming, so if you are in a hurry for a school science project you may want to reconsider and make a solar oven instead.

If all you need is a quickly made emergency or demo-still please read “The Cheap Solar Still” section next. Those are also not meant for long-term use, nor are they necessarily healthy if plastic is used (in fact, perhaps the opposite of anything I would personally consider healthy).

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Materials

Some of the materials you ***may*** **need** to make a solar still could include:

Plywood
Glass
Food-grade sealant (DOW-999A silicone—this is a special order item)
Nails
Screws
Nongaseous insulation
Wood (such as 2x4's, 2x6's, etc.)
Cement/concrete
UV resistant plastic or PVC (should not touch the product water as plastics give off toxins) for possible legs or for the box
CPVC for water trough or other water
Stainless steel
UV-resistant silicone tubing
PVC couplers/valves/connectors
Other miscellaneous items

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Materials to Avoid

*Rubber (toxic)
*Non-UV-resistant and non-food-safe plastics (they degrade and become brittle in the sun plus can put toxins in the water)
*Galvanized sheet metal (this will not last and the galvanization process/materials are not food safe).
*Cork (breaks down)
*Standard 100% silicone from hardware store
*Polystyrene (bead board—it gases off and crushes with weight on it)
*Any other foam or synthetic materials which are not food-grade or FDA approved as "safe" for food contact (especially if heated since stills can get quite hot!)
*Any other material which you are unsure about

When in doubt, do some research and ask and find out… do NOT take chances! Do your research thoroughly.

Pay attention to volatiles:

Be careful about what goes into your still—not only the water source but also the materials you use to build it.

Volatiles like gasoline or kerosene are not typically in groundwater, city water, or other sources of water; however, if one is in a survival situation where your only source of water is a puddle that has a thin layer of an oily substance that has a rainbow-like sheen to it floating on top (skim off as much as possible—try NOT to put this into the still), or your source water is a water well that has picked up some volatiles from the environment due to a natural or polluted source, then it is important to know that volatiles (chemical compounds or elements that have a low boiling point) CAN survive the distillation process.

Why? Because they actually distill out of solution before water does. Water itself is actually a volatile (as is nitrogen, carbon dioxide, hydrogen, and others), but water is necessary for life on earth, whereas people only *think* that petroleum-hydrocarbon related volatiles are necessary (our

society in the future will surely rid our dependence upon most of these as a fuel source) when in reality the human race has lived as thriving civilizations for millennia prior to their invention.

Petroleum hydrocarbon volatiles (made from crude oil) can include things like gasoline, kerosene, diesel, or jet fuel, and anthropogenic (manmade) sources of volatile organic compounds (VOCs) can include paints and coatings, aqueous solvents, chlorofluorocarbons and chlorocarbons (occasionally found in old cleaning products/refrigerants but are now highly regulated or banned), fossil fuels, benzene (sinks to low-lying areas, found in stored fuels, car exhaust, volcanic eruptions (beware of water contaminated by ash fall) and forest fires (water contaminated by smoke), and tobacco smoke, plus benzene is used in the production of resins, synthetic fibers, and plastics—so do not use these products to make your distiller).

Additionally, methylene chloride (in adhesive removers or aerosol spray paints), Perchloroethylene (used in dry cleaning clothes), and MTBE (banned in 2004 in the US to limit contamination of drinking water, groundwater /aquifers), and formaldehyde (in paints, wall boards, adhesives, ceiling tiles, and wood products) are also VOCs that you should be aware of, which could contaminate the still or product water.

If this scares you, it should. Carcinogenic poisons can come from 1) improper materials you might use to build the still itself by gassing off and contaminating the air inside the still, therefore condensing out of the vapor into the distillate/product water, or 3) direct distillation of volatiles could end up in the product water.

If you place a simple carbon filter (these are very inexpensive and can be purchased at your local hardware store) at the outlet tube, between the exit water trough/tube and the collection vessel (usually a glass jug) then it will remove any possible volatiles in your water and render it safe for drinking. It is a simple and inexpensive solution that acts as insurance against possible contamination from numerous possible sources.

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Mistakes People Make

There are a few pitfalls people fall into sometimes when trying to attempt the construction of a solar still for the first time, especially when they are unfamiliar with the process or materials, or in thinking that some materials are safe when they are not. Please read below and be careful not to make these mistakes:

- Using PVC instead of CPVC for product water (PVC degrades above room temperature and can put dangerous BPAs and toxins into the water)

- Letting the still run dry causing silicone to gas off and make a film underneath the glass cover (clean with a green scrub pad and a weak acid solution or Liquid Plumber or similar product, rinse VERY WELL! Then let the still run for at least 1-2 days before drinking the water)
- Sealing off the still when not in use – if you are leaving for a few days put plywood over the glass and pinch off the silicone inlet and outlet tubes so the still can be contained and not run dry.
-
- Not letting the still cure before using it (it takes about 8 weeks to let the silicone cure completely, or you can reduce the time by letting it run dry with plastic over the top (or use the glass, but it will have to be cleaned as per the instructions above after curing)

- Not sealing the glass well or not sealing the solar distiller well with silicone.

- Using standard 100% silicone instead of the DOW-999A FOOD-GRADE silicone (special order). Regular silicone is NOT meant to be used as a food contact surface!

- Not flushing the still daily – twice as much water should be put into the still as you get out daily, typically in the early morning just as the sun is rising, or in the evening at or after dusk. Flushing removes salts and mineral buildup from occurring within the still. This keeps maintaining and general operation of the still go very smoothly and as it will require less cleaning.

Now, to move on to the different ways to construct a still…

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THE CHEAP SOLAR STILL

The least expensive ways to build stills are by using materials you already have on hand. If you like to collect (or have a friend who collects and is willing to share) what other people consider as “junk” then you may already have a supply of materials which can be quite handy in constructing your still.

Also, the type of still can greatly increase or decrease the cost of constructing it. Usually, however, the cheapest stills are the ones that can be built or made in just a few minutes. These are typically not permanent stills, but are meant for short-term use, such as survival stills or ones made for school projects or science fairs, or even roadside breakdowns. They are NOT meant to be used long-term, and may not be healthy, as I stated previously.

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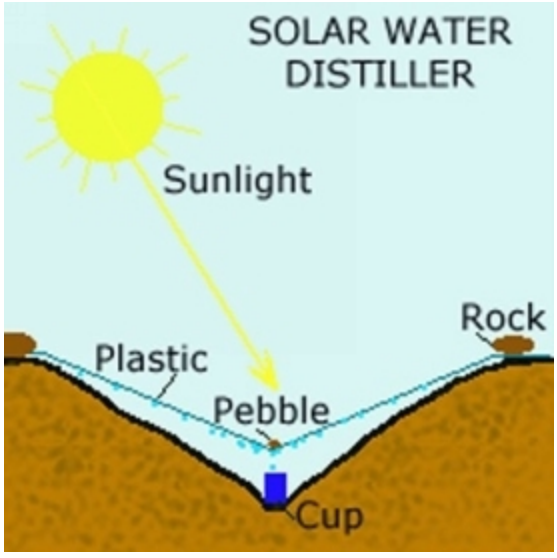
Emergency Solar Still

You can make a FREE or nearly-free solar still anytime or anywhere, even if you are stuck out in the hot, dry desert, as long as you have a clean (preferably a 5'X5' or comparable sized) piece of clear plastic with you. If you have some clear plastic on hand, especially food-grade plastic (an extra-large oven cooking bag may do) you are half way there. If not food-grade plastic, then this would be used as an emergency still only, otherwise it could be used longer.

STEP 1: Dig a conical hole in the ground and put a cup/glass/bowl/container in the middle of the hole.

STEP 2: Open up the plastic and stretch it out over the hole so that it covers the hole all the way (HINT: make sure your hole is not bigger than your plastic). You can put sand or rocks over the edges of the plastic to hold it down so it doesn't blow away.

STEP 3: Put a pebble in the center of the plastic to make the plastic dip down in the center, right over the cup that is underneath. Then sit back and watch your still work!



FREE solar water distiller out of a piece of plastic. Moisture from the ground collects and drips down into a cup or other collection vessel

The sun will come through the plastic, heat up the inside of the still (between the plastic and the ground) and cause the moisture that is in the earth to *evaporate.* Next the moisture will *condense* on the plastic, which will then run down towards the pebble and drop into the cup.

More water can also be made if vegetation or pieces of cactus or other plant material, or anything moist, are cut up and thrown into the hole before the plastic is put on. This gives extra moisture inside the hole so it can be distilled at a greater rate.

In emergency situations, and during war, people have also urinated into the hole to add extra moisture. Remember that only pure H2O evaporates and condenses so there is no worry for contamination (as long as you remove the cup so you don’t “splash” into it, and don’t splash or contaminate the plastic either). In just a few hours you'll have some hot water to make tea or soup, or let it cool down to drink it as pure water. Be careful not to burn yourself when you try this as it can get quite hot!

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Condensation Trap Solar Still

STEP 1: Another survival option is to get a large piece of plastic or clear plastic bag (or buy a transpiration bag), which you may keep stored in your car trunk or glove box or backpack.

STEP 2: Place the transpiration bag over a small non-poisonous tree or bush that sits in the sun, especially if it is near the bend of a dried up creek bed or wash/draw/arroyo.

STEP 3: After you have placed the plastic over the tree/bush then cup it at the bottom so that when the sun shines through the plastic it will heat up the air underneath, causing the tree to get hot and “sweat”. The tree, in trying to stay cool will give off water vapor and it will collect onto the plastic and run down into the cupped area of the plastic below.

STEP 4: After some water has collected you can retrieve it. Be careful not to let it run out onto the ground or you will lose the condensate! Also, don’t leave this type of still running too long or you’ll dry out the tree and kill the poor thing. Generally the water needs to be collected every two hours or the tree will stop transpiring.

NOTE: Be careful of what type(s) of bush(es) and/or tree(s) you use as some give off odors and gases that can make the water taste bad, or even be bad for you or make you sick. Soft (pulpy) roots may also be good sources of moisture, as are plants with soft leaves; avoid hard, woody parts or too many dry stems.

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THE BETTER SOLAR STILL

One of the first things I did before I built a still was by first reading everything I could get my hands on concerning this subject (I highly recommend doing that). Here is some of what I learned…

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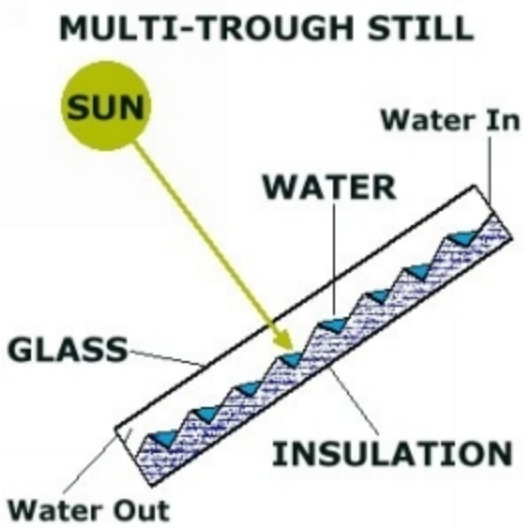
The Multi-Level/Troughed Still

Another type of distiller is a multi-level or trough type still. This is where, instead of one single basin, you have multiple smaller basins underneath a single piece of glass. Typically these stills are slanted at a diagonal angle rather than laid flat. The smaller amounts of water in these long but thin basins/troughs allow for rapid heating and evaporation of the water, but water must be added more often or the still will dry out too quickly. This can be done by a gravity feed tube or by automation and a drip-system.

I personally have found these systems to require more maintenance and attention (I like things that almost run by themselves) and so I tend to stay away from them; however, some people love their quick evaporation and condensation rates for a higher volume of distilled water in the same amount of time (as compared to a single-basin still).

I used to imagine spraying that Teflon coating onto the surface (since the product water will never touch it, it can withstand high temperatures, and will shed the mineral buildup easier than other surfaces) but I did not find out whether Teflon gasses off or could have any other potentially harmful effects or not, so never used this method. I recommend finding out if it gasses off or has any harmful issues associated with it first before you attempt to try it.



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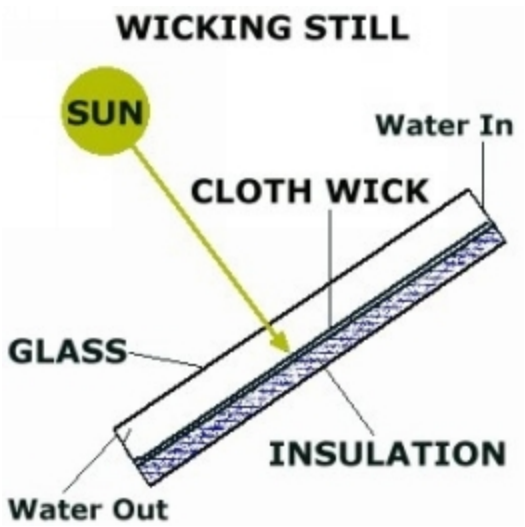
The Wicking Still

The wicking still is very similar to the multi-trough still in that it is a tilted still and evaporates smaller amounts of water at a time.

However, instead of troughs to hold the water there is a single piece of black cloth (natural fibers like jute or industrial hemp are best, definitely nothing synthetic as they can melt and/or gas off and even poison the food) for wicking the water through the length of the still.

Water is dripped into the top via a tube with tiny holes along its length. By the time the water reaches the bottom of the cloth most of the water should have evaporated leaving a salty white brine full of hard minerals, which drains out the bottom (you will want to keep this area clean so it does not clog or cause hard mineral build up).

The condensed distillate (or condensate) is caught above—via a collection trough—is so it can stay separate from the wastewater brine. Wastewater is one of the negatives about this type of still also, whereas a single basin still does not have this (although the basin will still need to be cleaned from time to time).



Like the multi-level still the wicking still needs more upkeep and maintenance, especially because the cloth gets clogged quickly with salts and build-up (calcium carbonate) and turns a bright WHITE, therefore the

heat-absorbing qualities of the black cloth is quickly negated and one must open the still often to replace this cloth. In some ways this is easier than cleaning the still because it becomes disposable.

However, not all is wasted if you let it dry and run it through a shredder and throw it into the compost pile to be recycled, adding calcium and other minerals back into the earth. There is no reason to live as a throw-away society when something can be recycled in this way (provided it does not have arsenic or mercury or other chemicals in it that you would not want in your garden compost).

Finding proper cloth such as burlap (fair to poor material) or something that “wicks” evenly is also a hindrance, although there are some natural or man-made shammies (i.e. chamois, or chammy) on the market that people use to wipe down their cars that wick up water very efficiently; however, they may not be cheap and I have only heard that people have used them, but I have not heard whether they work well or not. Check with the manufacturer to find out whether their product gasses off or has any potential for poisoning the water (I cannot repeat this enough for ANY product you ever use to make a solar distiller, especially for anything in the interior.

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THE BEST SOLAR STILL

It is said by many in the solar field that the single-basin still is the easiest and quickest method to build a still. The water sits in the basin and evaporates as the sun heats it up—simple! This is why I consider it one of the best stills to make… easy, relatively inexpensive, very few problems, and does not matter if the water freezes in winter (it will simply thaw the next morning and start producing again).

Yes, there are other designs that might be more efficient (certain commercial varieties, or hybrid systems, for instance), but what is your criteria? What is “best” for you and your circumstances may be entirely relative. Build to suit your needs!

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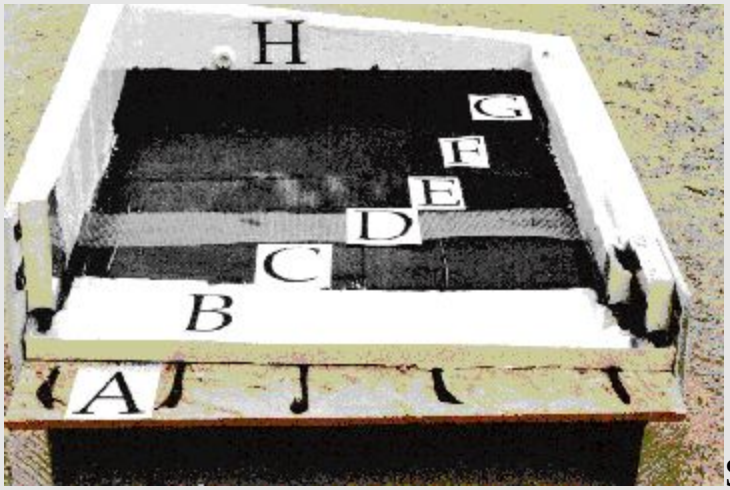
Single Basin Still

Horace McCracken was one of the first people in the country to really seriously work with the design of solar water distillers. He originally used concrete in his still design, but it was found to be heavy and slow in producing water due to the great mass of the concrete. He found that putting the sun's energy into heating the WATER rather than the concrete is the best way to go concerning efficiency. Just to note, however, that once the mass of concrete is heated up you will get a little longer time in nocturnal water production, so there is that slight advantage to concrete stills. Also, once the glass cools down from the night air, water tends to condense at a faster rate.

Horace McCracken worked closely with the El Paso Solar Energy Association in helping to design the best stills possible for one of EPSEA's solar still grant projects. Horace wound up taking some of EPSEA's ideas also, and started producing more lightweight and portable stills after that. A cutaway of this still is shown here:

EPSEA Solar Still Cutaway



Source: http://epsea.org/const.html

A- Base is 2X4 and plywood/osb
B- Insulate 4 sides and bottom w/polyisocianate
C- Waterproof membrane - 1st coat silicone
D- Fiberglass screen

E- Imbed screen into silicone
F- 2nd coat of silicone
G- 3rd coat of silicone
H- Side walls and trough (right) same steps w/white silicone and install fill/overflow and outlet tubing.

This “EPSEA Still” is no doubt one of the best and time-proven ways to construct a still, however there are some things you should know before tackling this endeavor.

Single basin still – note the gravity-feed trough attached to the back (made of house gutters)

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Important Rules for Making a Still

The water needs to be very shallow, perhaps ¼” to no more than 2” deep.

It is best if the basin is black as dark colors absorb more light and heat up faster. Light colors—especially white or reflective metallic surfaces—reflect the light and heat back *out* of the still. If the still is made out of concrete (thinner is best as it takes some time for the sun to heat a lot of mass (as in thermal mass)) and you can spread black cement coloring powder in the surface concrete itself, or paint it black with a safe, non-toxic, waterproof type paint; however, know some paints may peel within a short time, especially when they are constantly wet and the temperature is 150 degrees F (65 ◦ C) or better inside the still. Be careful not to drink the water from the still until the paint has dried/cured/gassed off all the way.

The main frame of the basin itself can also be made of wood with a waterproof food-grade liner of some sort. Some people also use glass to line the basin (with black underneath it) but be sure to seal the edges with *food-grade* silicone. This is a good idea but makes the still heavy and the glass may break easily if moved or something hits it. Glass may work better for permanently placed stills instead of portable ones, but it is an excellent way to get away from having to spend for special silicone, especially if you have access to cheap or free glass (HINT: Safety glass is best).

It is best if the glass that covers the basin is no more than 4”-6” above the surface of the water as too much air space can cause convection within the still, therefore making heat-loss a problem

Some people have put in a float valve like they use in toilets to regulate the water level. The pros of this are that it will fill a little at a time automatically (if a hose is attached) as the water level drops throughout the day). The cons are 1) the device could break and you could lose a lot of water or productivity, and 2) cooler water constantly being added to the still may drop the temperature enough to consequently drop still production, in some cases significantly. One fix is to preheat the water with a small

homemade water heater, or use an existing household solar water heater and tap it off of that.

Make sure that the glass above the water is tilted at about a 10-degree angle. Any more and convection occurs in the still; any less and the water will not slide nicely down the glass into the collection trough, but will drop back into the basin where it will become recontaminated.

Vinegar is an excellent way to clean both the interior and exterior sides of the glass and the still basin if/when needed. Rinse well before using.

Add a closeable drain so the still is easy to flush. Some people have put this in the bottom, but most put it on the side near the bottom interior surface of the still.

Insulate the (exterior) bottom and sides of the box with any water-resistant (non-paper) insulation such as aluminum-backed rigid foam insulation. As long as the basin is sealed from the outside insulation then gassing off (by the foam) should not be a problem. Remember that nothing can contaminate distilled water except what this ultra-pure water comes in contact with, OR toxic gases that are in the air and can permeate the water vapor itself. If you have volatiles such as gasoline, kerosene, or pesticides in the basin water then it CAN or WILL come through to the other side since volatiles have a faster evaporation rate than even water does. If there is any worry of the possibility of a small amount of volatiles in the water, then a simple carbon filter can be placed in the water tube/line between the exit trough and your collection vessel.

Make SURE to use a food-grade surface material such as stainless steel or food-grade silicone, CPVC, or even glass as the *collection trough* and for the *collection vessel*. The collection jug can be polybicarbonate such as those 5 gal plastic jugs but be aware that 140-180 degree Fahrenheit (60-82 ◦C) water is dripping out of the still at a constant rate all day long (especially in summer) and that it can absorb the taste (or toxins from the plastic) of the vessel it is contained within. Polybicarbonate jugs also degrade in the sun over time so make sure to shade it with a box or piece of wood or heavy towel or other opaque material. This will also help cool the water faster as it will now be shaded. Some people have their stills placed lower to the ground (like on cement blocks or a wooden frame/legs) and

then dig a hole to hold the jar/jug since the earth helps cool the water and shade the sides; however, the top will still need to be shaded or protected from sunlight. I personally do not ever recommend any kind of plastic for water storage, especially for hot water (and believe me the distillate exiting the still is HOT and can burn you!). I know that 5-gallon carboys (jugs) made of glass are hard to find, but keep looking, and stock up. Otherwise, use stainless steel or smaller 1-gallon glass tea jugs (some come with a spout) and change them out more often, or set up an overflow system to fill more than one at a time.

Always use food-grade silicone tubing for the inlet and outlets so that the tubes don't crack and break in the sun. Don't ever use regular garden hoses for the tubing as it has rubber inside and will make the water smell and taste terrible, and will poison the water.

EPSEA solar water distiller

The "EPSEA" still utilizes food-grade silicone (DOW 999-A) which is a *special order product only*. Cost is about $10+/tube and it takes about 24

tubes to make just the silicone “liner” of the still, considering it takes 3 layers of silicone for completion. Then the silicone needs to cure by outgassing (best if put out in the sun for a few weeks/months); the time can be reduced by setting it in the sun with the glass on (without water in it).

Mike Cormier (on left at corner of still) teaching a solar distiller construction workshop at a solar energy fair. They are installing the mesh over the layer of silicone.

Spreading the white silicone on sidewalls

Sealing corners with DOW-999A food-grade silicone

Last layer of silicone for liner
(white for sidewalls, black for basin bottom)

Mike Cormier showing how to attach silicone tubes and bucket (optional) for feeding water into inlet hole to fill still with water once it is cured

Distiller with glass attached. Robert Foster (Renewable Energy Engineer and lifetime member at EPSEA) on left, with Gerald Martin (volunteer) at end, both speaking with interested gentleman (right) about stills.

When you pre-cure the silicone and if the still is run "empty" of water then the silicone can outgas causing an invisible film on the underside of the glass and the purified water production will go down to almost zero until it is properly cleaned off (glass cut off and flipped over, or else cleaned with Liquid Plumber (or similar brand) and a soft scouring pad – use HEAVY RUBBER GLOVES and do NOT touch this stuff as it will

burn your skin!) until the film is removed. RINSE glass thoroughly and let the still "run" with water it in afterwards for at least a full day before drinking any of the distillate. The last thing you need is poisoned product water.

If you do not use food-grade products such as the DOW 999-A silicone then make SURE that what you do use is safe and doesn't leak. Some prefer to use stainless steel, however this can be quite expensive also and you must be sure to use high quality stainless steel (316 or better) because low quality stainless can pit and corrode over time.

Another item that is hard to get is the silicone tubing for the inlet and outlet tubes, as well as the overflow tubes on the still. The tubing itself is readily available; in fact, most companies that sell it do so in entire ROLLS rather than just a few feet (which is all you would need). Why buy a $50 roll of tubing if you only need 3-5 feet of it?

A solar still Rainkit™ 990 (for the hard-to-find items) to make the EPSEA still can be bought from SolAqua for around $245 http://SolAqua.com/SolAquakit2.html

(KIT comes with the EPSEA still construction plans).

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COMMERCIAL STILLS

There were many fly-by-night solar companies and new products that presented themselves during the 1970's due to the solar credits, which were paid by the government for solar contraptions of many kinds—this being from solar distillers to solar water heating to solar heating of homes, and other interesting inventions. Many of them did not work well because they were not fully researched and developed or tested long enough in the field before they were made and sold, and many of these companies could not guarantee their work with a warranty.

Many of these companies went under and closed down due to their products being inferior. Still yet, there were some gems, and the information gleaned about what *not* to do concerning solar projects and programs, became evident to the masses over time, so ultimately I am personally glad for that "learning experience" time in America's solar energy history. Some of the solar distillers that did not work, and some that did, were carried forward and eventually tweaked and updated again and again, until either the most complicated and expensive, or the most simple and inexpensive designs were in place. Only the ones that worked best tended to stick around.

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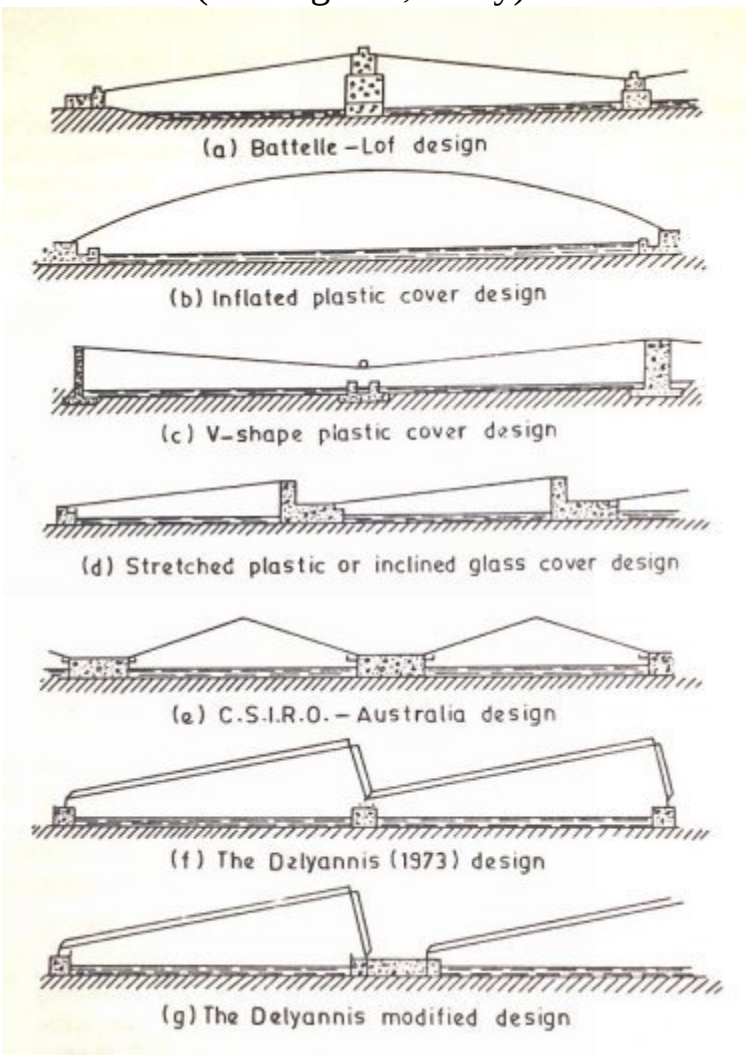
Multi-Trough or Array Style Stills

Today we have some excellent choices and knowledge about the engineering and efficiencies of solar water distillers. Some of the methods that are tried and true today were only slightly adjusted because at one time they were not the standard (nothing was, really).


(a) Battelle – Lof design
(b) Inflated plastic cover design
(c) V-shape plastic cover design
(d) Stretched plastic or inclined glass cover design
(e) C.S.I.R.O. – Australia design
(f) The Delyannis (1973) design
(g) The Delyannis modified design

Picture source: *Solar Distillation: A Practical Study of a Wide Range of Stills and Their Optimum Design, Construction and Performance* (Malik, Tiwari, et al., 1982)

The picture above of some of the styles of glass, for instance, were used on commercial stills for many years, even into the 1990's, and some of them are still used today. However, we know now that glass that is set perpendicular to the sun's rays has a much better chance at going through and heating the water than glass that is set at an oblique angle to the sun,

which impedes sunlight and slows down the process of heating, and therefore distillation.

Plastics, especially back in the early days, were probably not as food-safe when heated as some food-grade and microwave/dishwasher-safe plastics today, and glass was typically used anyway.

The famous “tent”, or double-slope still design (where there are two pieces of glass on top that form a double angle with a peak in the middle, like a tent shape—see Battelle-lof and Australia styles in picture above) can work great for one side as it allows the sunlight through, depending on where the sun at any given time of the day, but may be working fairly inefficiently on the other side if the angle of the sun is wrong. This is also known as the “classic” style solar still.

These style stills were often made in long troughs that ran north and south (so the sun would hit them fairly evenly as it traveled from east to west), and these long troughs were placed side by side, like rows in a vegetable garden. The glass “tent” peak would run down the middle above each trough, and the sides (lowest point of the glass) would have a small channel or collection trough just for the distillate/condensate. These troughs would run down the length and collect in pipes and eventually cisterns or tanks or some other holding container for later use of the product water.

The multi-trough stills, all set up in an array of sorts, have been made out of different materials (usually concrete) and can produce many, many litres/gallons of water in a day’s time. The good thing about these is that they are passive in nature, although fans have been attached to the end to allow air to run through the middle (some heat loss may occur). These stills are often found in developing countries to aid bringing pure water to villages that suffer from a lack of potable water. Saline or salt water from the ocean is what is usually placed in distillers like this.

I also spoke with an inventor once who had designed a bubble style still once that had a round tube-like shape to it that the sun could shine through, which would heat the water inside and cause it to condense and drain out the far end of the tube (I have seen other similar designs). Because of proprietary information that was told to me, which I cannot repeat here, I cannot give any more details about this still, but I can say that it worked well and produced more product water than a typical passive solar still

would. However, this prototype never made it to the market, nor was a company formed to produce it for the masses.

Things have come a long way in the last several decades. I have watched most still companies (charging $800+ per still) come and go over the years. I have no indication as to whether the ones here today will still be here tomorrow so I'm going to tell you that in order to find them just do a search on the Internet.

That said, there is one company that I will mention here that we used for our solar distiller grant projects that continues all of these years later to make distillers and even has a one-year warranty on them.

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Single Basin Passive Solar Stills

The **RAINMAKER^{TM} 550** is made by SolAqua. This is the same company who sells the KITS I just mentioned. We installed Rainmaker solar stills in the EPSEA solar still grant projects as well as the EPSEA homemade stills.

Photo of a SolAqua distiller I installed in El Paso, TX

SolAqua took the EPSEA solar still and improved upon it greatly, adding in awesome features such as a second overflow trough, a special one-piece silicone liner which has outgassing reduced from 60 days down to a mere 2 days! Now, if the still accidentally runs dry any film that may be there will just simply wear away and vanish.

Another feature I really like is the removable trim that holds the glass in place, because it makes it tremendously easy to clean the still. In homemade versions the glass is silicone on, so it has to be cut off, cleaned, re-siliconed on, and then run for a couple days before it can be used again.

Notice the 1-gallon glass jug from supermarket used to collect the product water via the silicone tube exiting the still. This is a 2'x4' still.

Two stills juxtaposed reminds me of the quote:
***"…why build one when you can have two at twice the price*?"—S.R. Hadden**
Played by actor John Hurt (movie: *Contact, 1997*)

These stills are lightweight and easy to handle. Stills can also be automated using sprinkler systems and connections available at your local hardware store. Once a unit is bought it can be set up in a matter of minutes. These stills produce about 1 ½ - 2 gallons per day during summer, and half that in winter in most climates that have 5-6 of solar peak hours per day.

RAINMAKER^{TM} 550 Solar Still

For any further information or to purchase one of these stills please see www.SolAqua.com.

If you choose to build your own still, then I wish you the best and please have fun; the reward is clean tasting ultra-pure water for years to come.

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Hybrid Family or Industrial-Sized Solar Distillers

Earlier in this book I mentioned that my friend and colleague, Hill Kemp (engineer), had installed a prototype of his new still design at my house in El Paso, Texas. I have an acre of land, so there was plenty of room for him to dig a large hole and install his new creation. I understood the concept of a hybrid still, and expected it to work well, which it did!

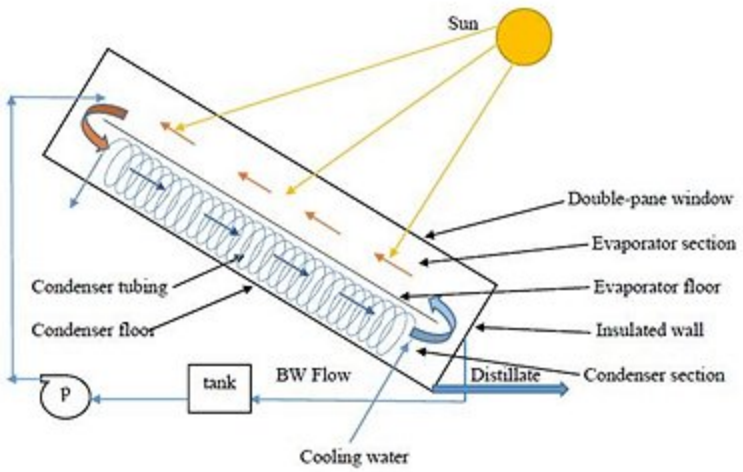
After about a year and a lot of testing, data collection, and going through the numbers, he removed the still as promised, filled the hole back in, and left my yard as if it had never been there. I am pleased that he was able to do this on my property, and consider him an excellent designer of commercial stills.

You see, I know something that most people do not know, and that is the concept of wind making things cooler (in nature)—like the cool glass inside a still—and its effect on the condensation part of the distillation process… but it has to be engineered just right for it to work correctly. I learned it by making many phone calls and talking to just the right people at the right time, so when he told me about his still design, I knew already what he was doing, and grasped the project without ever having to see it in person.

The concept and design was excellent, and still is. He has tweaked it even more since then, so I am happy to present it to you, with thanks to Hill Kemp for the use of his pictures and information for:

The Suns-River Solar Distiller

(see picture next page)



Suns-River industrial-sized commercial still

I am very excited to show you this design because it is made specifically for families or even large-scale projects such as factories or military facilities or larger businesses—even cities!. The larger the product water needs, the larger the array of stills needed to produce the water. The Suns-River stills are perfectly scalable.

The difference between Suns-River stills and a passive single basin type of still is the fact that it is a hybrid (combination between passive and active solar—active means there are moving parts or mechanical pieces). The still itself is passive because the interior of the box has no moving parts, but externally is a small pump that uses solar PV (photovoltaic) panel(s) to produce the electricity for the pump.

Suns-River hybrid solar water distiller

This still, when comparing its square feet of sunshine to the same square feet of sunshine in a passive solar still, will produce several times the amount of product water, just because it is designed so efficiently, and yes, it is a patented design.

One particular feature is impressive, because although this is a hybrid still, it technically is, according to the Suns-River website: "…*the only desalination technology with no internal electrical or mechanical parts and 100% solar powered*" and produces about 1 litre per hour.

Hill Kemp told me this:

"*Our single-wide 2.75 m2 unit actually produces about 25 liters/day, enough for cooking and drinking for a family of four. We hope to get the refined price well below $999. So it's not confined to industrial. With multiple units ganged together we serve industrial and larger uses .* "

Now, you are in for a special treat. About a month or so after the publication of this book Hill Kemp was interviewed, and the link to the long audio file was placed on the suns-river.com website. I listened to it all very carefully and took notes! I am including those notes below.

I have not seen a more efficient solar still on the market to date, which is completely off-grid and overcomes many of the old inefficiencies associated with the old fashioned classic “greenhouse” solar still. Enjoy!

Hill Kemp Solar Still Interview Notes

From Sept 2015 radio show interview linked from suns-river.com

Deserts have millions of gallons of salt water underground, but it is too salty to drink. Stills excel best in deserts. Stills can also easily be used to desalinate ocean water, of which there is an unlimited quantity and availability on earth.

Aristotle documented around 350BC that when a cover is placed over a dish or pool of salt water, the condensation on the inside of that cover is pure, salt-free water. The salt says with the pool. He also said it was lousy way to make fresh water because productivity was so poor.

The classic solar still (greenhouse style—tent-like shaped glass cover) over a pool of salt water performs okay but people give up on them after a while. Survival kits for boats—these are about the only viable application around for a solar still in that circumstance. The salt in sea water, if drunk, demands more and more moisture out of you, so is basically poisonous. That survival kit will produce a small amount of water to keep someone alive temporarily.

Hill Kemp took technology, broke it down into six steps, then micro-engineered to make these steps more efficient in his solar still to produce more water than the classic solar still. Every square meter of glass surface in a classic still can produce 3-4 quarts or liters per day. Three of the six steps were severely restricted, so he changed equipment to eliminate the bottlenecks. So now the Suns River still productivity is 11-12 liters per square meters of glass surface!

The classic still is a greenhouse over a pool of water and the six steps are:
1) sun shines through the clear roof,
2) Solar energy heats the bottom of the pool and warms the water at the bottom ,
3)warmer water drifts to the top of the pool,
4) evaporates across the air space inside the greenhouse and

5) condenses on the inside of the greenhouse glass, and
6)a gutter at the base of the tilted glass collects the pure distilled water.

Greenhouse roof has two purposes: let sunlight through and condense humidity on the inner surface of the glass. Why is that inefficient? Because droplets on the inner surface diffuse the sunlight and take away productivity. Suns River changed this so there is no condensation on interior of the glass in this design. We tried coatings but double glass is what we went with. Control temperature so the interior glass is too hot to condense water. We have a sloped "falling film" of water rather than a pool. The film is 4/10ths of a millimeter thick, cascading thin film, so when solar energy hits the floor the water evaporates quickly (4x as efficient). Further, we use tubing coiled in a flat configuration under the evaporation floor and run cooling water through the tubes. With an air space at top and bottom of the sloped floor, humidity created inside the still goes up (chimney principles, convection) on top of the floor then down-flows on the back by the cooling tubes, so there is natural internal circulation inside the still. Hot air up, and cooler dryer air goes up the floor (closed circulation).

We start out using salt water as the cooling water (tank full of cold water in the morning), which is all that is needed to condense the water for the whole day. During the day cooling water heated by condensation in the solar still is stored in a classic style still—a salt water pool with a greenhouse cover. That equipment does its usual lousy job during the day, but at night temps drop 25-30 degrees F (day to night) and overnight that hot water is only insulated from the cold night desert air by the greenhouse roof, so it pulls energy out and condenses like crazy (second effect). Cools the pool off so by dawn the tank water is cool, it is transferred back to the cold water tank and starts cycle again the next day.

RECAP: At dawn begin with tank-ocean water/saline water—coolant, recirculate water through the still for condensation then into second tank for “second effect” tank with transparent roof – 40% of distillate is from the second effect. That solar heated water is like a charged battery. The second effect does two things: produces more water, and cools off the pool for use next day.

Thin film of salt water on floor that receives solar energy throughout day, flows down black sloped roof. There is a closed salt water circulation and goes around and around. In the late afternoon stop adding make-up to that concentration (3000 parts TDS (total dissolved solids)) and concentrate it up to around 100-150,000 parts. That concentrate is put into a thin pan in 1/2" layer of water in thin pool, and in 2 days evaporates and is dry salt. Sulfates and salts (not sodium chloride) mix from ocean water.

That pan of salt condensate… the idea is to build it up over time to a 3" thick layer, then perforate on 3"x8" matrix, then break up into bricks. Build a building, stucco, and you've sequestered the salt. Like a salt brick "adobe" structure. Depending on what your feed stock the salt could be used as road salt. But 2/3rds of groundwater in New Mexico has more arsenic in it than what you can drink safely. What is left behind in pan… If composition of salt is okay then use for road salts, some like it for its mineral content. Potential building material.

A Las Cruces, NM artist suggested a round pan to begin with, build up as it goes with different form shapes and make a sculpture. Can't go very high with mold at a time, and the salt is built layer by layer.

The product (of the solar still) is pure distilled water. Free of minerals and bacteria. You have to add minerals back to distillate to make it taste right because it's devoid of all minerals. 93% of feed water winds up as distilled water from the still and second effect. You can increase productivity by using feed water to add minerals. But that depends on the quality of the water coming in. If there are poisons in the feed salt water you don't want to make the saline content of the product too high.

Small remote areas that do not have standard access to clean water. How do you scale this up to something like southern California on a massive scale? Scale and application—4'wide X 10' long X 1' thick box will supply water for family of four. Decentralized on-site system for drinking and cooking purposes. Modular designed equipment in standard units.

Add modules together: 3 modules x 8 modules put together, raises productivity tremendously. Multiple-effect distillation, multi-stage flash, membrane distillation, all need a source of hot water. Still creates this

source to run multiple processes. Adding modules is what it would take to produce water for a small city. Need land available can put 24 modules together and feed into multi-stage flash or multiple-effect distillation... 20-50,000 gallon range or higher. This is completely scalable, based on amount of square meters of glass made available to the sun. Tiny model portable unit which fits in a briefcase still works (1 quart per day).

Use a pump for pumping water up the slope—1/50th of a horsepower swamp cooler pump. Also cooling water through tubes needs pumped, all can be done by PV cells. New Mexico unit for contest was completely off-grid and ran strictly on solar energy. Pumping occurs during day, so only works while the sun is shining, then the second effect takes over, then in the morning you pump the second effect water back into the tank and start over.

People are concerned about the thin film of salt water and a crusting effect, but we have commodity amounts of distilled water, so once per week or month we start off with distilled water in the system (hot water) and it dissolves the salt that might be in the system and keeps it from building up.

No internal or moving parts, just an external pump. We can automate it—we ran non-stop 13 days with only simple timers. We had to stop for 4th of July holiday. When you use hot water for multi-stage flash, then that is more complicated. Our process can create a geothermal-like energy source anywhere. The hot water that is produced is like a source of that coming from nature but it is solar heated.

We have not explored making electricity production regarding the still, and focus on solar water distillation only. Electricity usually requires steam power and our still is designed for optimum distillation output of water, not making steam.

You can grow plants in the desert utilizing our stills too. Deserts are short of water, and shade, so desert application: 3 high modules, 1/2 meter space between rows. You can create a large space underneath the still that gets partial sun, which allows you to grow all kinds of plants that would normally not grow in the hot desert full-on sun. So you now have partial shade and a water source.

People are worried about economic collapse or the apocalypse, or just being self-sufficient. At the family level, the still can be used for as long as you need it. Life-cycle can run 12-15 years. The floor material that maintains the film might need some work or maintenance during that time, or the pump. Everything else—the box, the cooling tubes, etc., will all last over 15 years.

Hill Kemp is a chemical engineer, and started out on this project because of global warming. People have been trying to slow down or halt or reverse global warming. Because of this process and its peculiarities, it can be done on a very large scale. Cold ocean current offshore of Morocco (Canary Islands current) actually creates the Sahara desert, condenses all the moisture of the incoming weather, so it cannot rain past this area (called the rainshadow effect). High mountain ranges also create a rainshadow. My process needs cold water and good sunlight, and this is what these areas have.

Can grow renewable forests in 90% of that area using sea water as the source water and cleaning it via distillation. I have a voraciously growing tree species chosen that has a 75% growth time of a southern pine, which will grow well in these areas. Trees can replace what we have lost in tropical rainforests. CO2 is converted to sugar and releases oxygen. They can store 24,000 tons of C02 per acre. [Trees are the lungs of the planet. The desert has been there a long time, and it can be turned into an oasis.] You can create an economy where there was no economy, especially when millions of acres of idle desert are available. If you get a drip in a water line 1-2 trees spring up naturally.

Could create a one-acre scale in NM but the sad part of the story is... I was in a contest and they got 69 entries in 29 countries around the world, and my still was in the top 6, but I was not able to raise enough money to build the unit to compete.

Been building these one at a time but they are designed for assembly line production. They should price out between $600-900. A still for a household may be a little over $2,000.

Contact Hill Kemp at www.suns-river.com [I recommend investors contact Hill personally]

Am working with UTEP (University of Texas at El Paso) to license the technology, contact Melissa Silverstein: msilverstein@utep.edu

Biggest road block now (have had grants from the government (put up 40% cost, he put up 60%), working with UTEP) is raising capital. Need the capital to begin the project at a larger scale. Our technology is so far outside the box and does not have a lot of gadgetry to it. Simple and off-grid. People want complexity in technology, but this is simple stuff. The National Renewable Energy lab and people think it's too simple and cannot get over it.

People could collaborate or team up to help with capital. Can build the unit and have it in operation in California and around El Paso, Texas for $40-50K. The full-fledged business probably around $2M.

Another application: a lot of people in the desert country learned they can grow pecan trees from irrigation water (has salt in it), about year 8-10 yrs the salts kill the trees. I have been working with folks to once or twice a month to water with distilled water because it dissolves the salts around the roots and rejuvenates the trees. So an occasional regimen of a distilled water flush can lengthen the life of the trees.

500p tds is what people expected for drinking water. If feed water is safe then this is doable. Distilled water is mineral free and virus free. You can drink it right off the still. No concerns for E-coli or other pathogens.

www.suns-river.com

Capital raising is going in with bartered rates right now.

I own three US patents and share two more with UTEP, and also is patented in Australia and India. I own this technology, so any partners stand to benefit from my intellectual property for a promising venture. Have spent six figures on patent lawyers with my social security checks to get this far.

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BEYOND DISTILLATION

I personally did not feel that this topic about solar water distillation —making your own rain—would be complete without touching on a few more methods regarding the process of evaporation, condensation, and collection. Namely because technologies exist that many people worldwide are taking advantage of to purify water or produce it from thin air.

Yes, you read that right… you can produce water from the air, sometimes passively, without any electricity whatsoever. Dew and fog collectors fall into this category. So does collecting the water from earthtubes (I cover this in a separate book), which is a design I have played with for years, but not yet had a chance to utilize. Rainwater harvesting is yet another method I will talk about briefly, but first, fog collectors.

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Fog Collection

There is a non-profit organization in Toronto, Ontario, Canada called FogQuest (fogquest.org) that utilizes sustainable methods for condensing and collecting water from fog. They report on projects occurring all around the world, from Guatemala to Yemen to Los Angeles, California.

FogQuest has also reported on how places like Japan have researched issues like fog chemistry, specifically in regards to acid fog and forest decline, or how fog drip is important to the ecosystem in humid climates. In places like Costa Rica or Puerto Rico they have fog/cloud forests, and experiments have been forthcoming for large fog collectors that can even withstand high wind speeds in Africa.

Places, people, and events that have shown interested and research or promote fog collection have included students doing their undergraduate or graduate thesis at Oxford University, international conferences on rainwater catchment systems in Mexico City, people doing fog deposition studies at the Free University in the Netherlands as well as the University of Bern in Switzerland.

World Water Day or Fog Conferences are events where you may find fog collection efforts being displayed, and people who utilize dew collecting methods also include groups involved in community services, social development, universities, churches and non-profit organizations (like FogQuest) or other NGO's (non-governmental organizations), Social Justice groups, governmental entities titled as the Department or Ministry of Agriculture, or other environmental, food, or water related groups or individuals.

Interestingly, fog is not only studied or harnessed in the cooler or wetter climates, the Desert Research Institute in Namibia and other desert climates (especially near the ocean, like in Chile where fog collection is popular) are able to harness water vapor for collection and use it as a water source, sometimes for entire villages.

“Fog Catchers”
Picture source: http://inhabitat.com/possible-solutions-to-tackle-the-california-drought/

Often these fog collectors look like a large square or oblong-shaped screen material stretched out onto a frame, with a collection trough underneath to collect the condensate. They typically work best at night when it is cool, just like how dew forms on the blades of grass and on plants in the cool of the evening. That is why these devices are referred to as both dew collectors and fog collectors.

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Geographical Considerations for Fog Collectors

Like the air that cools and condenses water vapor into droplets within a solar distiller, air movement and wind are what carries clouds and fog through fog collector screens, along with topographical features (both large and small) are crucial features in having a fog collector (also called a fog fence) that works successfully.

Here are some of the features and circumstances you will need, based on experiences of those with fog collectors from the 25+ countries that use these methods that collect water for drinking, cooking, bathing, and irrigation purposes:

- Global wind patterns, trade winds, or persistent winds
- Mountain range that intercepts clouds, or isolated hill
- Altitude—typical altitude is at two-thirds of the thickness of the clouds for optimum moisture levels, usually ranging between 400-1000 meters above sea level.
- Orientation—it is best when the longitudinal axis of the mountain range is perpendicular to the wind direction. Clouds flow over ridges, through passes, and dissipate on the downwind side.
- Be as close to the coast as possible… 3-15 miles (5-25km) is the typical drop off rate, although these furthest distances work well as long as fog and upwind clouds pass or form there.
- Flat-topped mountains, ridges, and upwind edges are best locations to install fog collectors. Several meters of space (at least) should separate individual collectors in the array.
- No obstacles within a few miles of the array, upwind of the site, should be present. Winds will divert around ridgelines and other obstacles, reducing collection potential. A local basin may heat up during the day, creating a low pressure area, which can improve sea breeze speeds and help move clouds flow over the terrain.
- Prevailing winds force winds up valleys and cause wind direction changes. If the inversion base is below a ridgeline

then passes may serve as a good site.

- Studies show that site locations along ridges or crestlines, or just barely above the crestline, are optimum. Avoid a downslope wind flow.
- According to Natural Resources Forum (1994, vol 18, no 2), where this information is gleaned, “Gently rising slopes upwind of the collection sites are ideal.” Steep slopes make collection difficult. Also, where small valleys, large boulders, or lots of small hills are present the collectors may not function properly.

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Mimicking Nature for Fog Collectors and Distillers

As you may have noticed, there are definitely some features within fog collection, where physics in nature is involved, that mimic the best possible situation for solar water distillation as well, at least as it concerns evaporation, condensation, and collection (at least in how my mind works and makes connections and sees patterns). Some examples…

A single basin distiller holds a small body of water, similar to the large body of water that is the ocean near fog collectors. In effect, by making a solar water distiller, one is copying what nature already knows how to do by recreating a miniature landscape with just the right elements, and harnessing its power to reclaim that moisture for practical use, just on a much smaller scale. The same goes for fog collection, except the ecology and geology and geographical features are already there and one simply recognizes it and places the fog collectors at the best possible collection sites, then causing condensate to form so it can be collected in a trough for storage.

In the case of distillation, moisture is created by heating the water with the sun and causing evaporation, which condenses on the cooler glass above the water. For fog, the sun heats the ocean and causes evaporation, which cools by winds and topography, forming clouds/fog that condense on the mesh or parallel wires of the fog collector.

I personally find it interesting that, like solar water distillers, where a slight incline in the glass (about 10 degrees) is present, fog collectors also work best when the land is at a slight incline. Both have to do with circumstances for optimum condensation rates. A still with glass too steep causes convection, and therefore circulation patterns within the still that disrupt the gentle condensation process. A hill with too steep a slope or rough topography similarly cause disruption in the wind patterns and reduces collection rates. A still with glass laid too flat will cause the condensate to fall back into the basin rather than roll down into the trough, and a flat landscape with not enough wind will not cause enough cooling for condensate to form on the fog collectors so it can drip down into the trough.

Both distillers and fog collectors work on similar principles but stills are a bit more versatile. Fog collectors tend to be limited by and are dependent upon location, terrain, wind patterns, moisture levels, orientation, and temperatures. A solar still can be placed just about anywhere, as long as there is sunshine. A limitation to a solar distiller would be having enough water to place in the distiller to begin with, whereas a fog collector, if in the right area, can produce water from the air itself.

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Dew Collection

Although fog collectors are a type of dew collector, not all dew collectors collect condensate from fog. Nighttime dew that forms on plants, without the presence of fog, is an example.

A *dew pond*, like fog collectors, is usually in a depression on top of a hill, and is artificially made. Originally intended for watering livestock, dew ponds are utilized when natural sources of surface water are limited or nil. Dew ponds are also called *mist ponds* or *cloud ponds*, although they are actually not filled by mist or fog as much as they are by rain (that is important to know).

Dew pond near Chanctonbury Ring,
West Sussex, England
Photo source: Wikipedia

The saucer-shaped dew ponds are typically made out of natural materials, being lined with chalk or marl, puddled clay, or chalk/lime that is insulated on top with a layer of straw; however, some dew ponds are made out of cement or concrete.

The layering is not only used to collect the water, so that it does not pass through the ground and get lost, but also to deter burrowing animal, including earthworms. Clay is a commonly used near-waterproof barrier if it is done right. Sometimes soot is also used with lime and mixed with the clay. After the straw is laid down to protect the lining from sunlight, which

could cause cracks, a chalk rubble is placed on top of that to prevent livestock hoof prints from damaging it further.

The concept is fairly easy, the pond is used to trap water and retain it, and cool air captured in the low setting also helps prevent evaporation. Letting grass grow long or placing it in a hollow also helps restrict evaporation. Dew ponds have a long history and go back before antiquity.

One could imagine how using a depression in the earth's surface that collects water could work in tandem with a solar water distiller that uses rainwater or similarly collected water to purify it further for human consumption.

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ABOUT SOLAR WATER DISTILLER CONSTRUCTION PLANS

I have shared pretty much all of the information that I know and have practiced with the years I have had as the Project Manager for EPSEA in the grant projects for the solar still projects, as well as personal experience in designing, building, and using solar water distillers (I do not ever plan build a concrete still again—boy is that work!), as well as in training others and helping with solar still construction workshops. I have cleaned umpteen stills in the field, and installed well over 100 of them personally.

By now you should have a good idea about how solar stills work, and with the cutaway view, and pictures, and examples I have given you could probably build a solar distiller using just the information in this book. However, if you still feel the need to buy an actual set of construction plans in order to construct one on your own, then I would recommend splurging to buy the original EPSEA solar still construction plans (I have it in the old newspaper printed version).

For years EPSEA had these available for sale to the public. There are three options for getting the original EPSEA (although no longer available through EPSEA because that organization is now basically gone) distiller construction plans, depending on your choice of media:

1. **Digital copy (PDF instant download)** available through my website at www.sunstar-solutions.com (these are the exact same plans, except that instead of a newspaper-style or spiral-bound set of plans you can get it in PDF as a download—you may print on regular paper (great if you get it spiral bound for easy use)) or via Kindle ebook reader.

2. **Printed copy 8 ½ x 11" book** available through my website at www.sunstar-solutions.com (includes extra information and pictures not available in other media forms) or Amazon.com.
3. **SolAqua spiral-bound printed copy** available for through www.SolAqua.com

I hope you have found this book useful and that your solar still construction goes well.

A supplemental chapter follows about problems in colonias for those with further interest in the subject of social justice and clean water in poor or rural areas. The struggles of communities continue… I offer ways in which you can help, no matter how small the gesture, even if it is only by giving someone a copy of this book.

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PROBLEMS IN TEXAS COLONIAS

I do not have a problem with rules and laws that are meant to help people and for the betterment of society as a whole, in fact, I was the former Social Justice Committee Chair at my previous UU church until 2010, and also helped with community water projects in west Texas/southern New Mexico colonias when I was the Organizing Assistant for Border Interfaith; we worked within the rules, and met with people in power (at the city, county, and state levels) to gain city water lines into some of these areas. However, when the laws meant to protect people wind up victimizing them instead, then I feel it is my duty to stand up and give voice to those who may not know how or have the means to do so themselves. I am not an activist, and am not an advocate, but I am a writer and so this is my contribution.

It is my love for ALL the people of this beautiful earth, and the part I have played in this story (whether installing solar distillers, or living in these areas with deficient water and impossible rules, etc.) that brings me to my knees in sorrow and regret that human rights and basic needs for quality of life are not met.

Water is life, and should be a right, not a privilege, because without it people die. When it is available but is polluted or deficient, then people get ill or die. It is not just water that is important… electrification, in particular, holds significant value in freeing up people from the conditions of poverty. Areas that are developed find growth, and improvements, and all neighborhoods in the entirety of America—from coast to coast, and border to border—have, at one time, begun as a rural single dwelling that someone called home. Whether that was a tipi (teepee), wigwam, or longhouse by Native American Indians, or by a settler that crossed the prairies by wagon and built a sod house, or whether it was a log cabin at the Rocky mountains, or a wooden shack built in the desert by a railroad track, these areas are

now called “cities” such as Sioux Falls, South Dakota (or other major city in another state where Indian tribes lived), or Omaha, Nebraska, or Denver, Colorado, or Phoenix, Arizona, respectively.

It is no mystery that times were hard in the past, but for some people today, it is just as rough. The homes that were built in the past always had to start with one, and then more were added, and in time villages turned into towns, and towns into cities, and modernization ensued, until today we have people who hang out in Starbucks and play games on their cell phones using the Internet. So much is taken for granted that to not have these luxuries must be a crime! No? Perhaps in some peoples’ eyes. They are labeled and turned into “the other”… as if sub-human. Verbal lines are drawn in the sand, and delineations of quality and worth are struck by the gavel or written in by the pen.

People in political power and common citizens alike must realize that some people *choose* to live rurally, and off-grid (the electric grid), and that their choices need to be respected, and their lives not quashed. In some cases it is all they can afford, or want to afford. In other cases—like for children—there is no choice. As a thinking, feeling, conscious society we have a responsibility to each other, to help when possible, and lift each other up. It is important to believe that tender circumstances today could improve and be strengthened tomorrow. It is important to know that most all American cities started out rural and poor and few in number for population. Rural communities today need to be given a chance to succeed as well. They need tools for survival, and education to build capacity so they can prosper.

Despite the fact that I am not blind to the problems in colonias, I find issue not with how people are living, but that they have trouble finding the resources they need to improve their lives. There are numerous reasons for this. My experiences and discussions with colonia families are more geared to helping people, and seeing them as trying to eke out a living like anyone else, just with far less money, plus due to colonia laws that often seem to do them more harm than good. This is particularly true in Texas where I am from.

I have to say that as a cultural anthropologist I have a bad taste in my mouth regarding the stereotypes about colonias that abound, especially among lawmakers and the media—most of who do not even live there—

who portray them as filthy and vile, when rich people (ranchers and farmers and business owners that are well to do, for instance) live there too. There are a good many people who have clean drinking water (even if they buy it or purify it), flush their toilet like any other person in a developed nation, use their dishwasher, turn their thermostat up in winter, turn on the A/C in summer, charge their cell phones, play video games and watch TV, have a full working kitchen and appliances, and bathe or shower regularly like anyone else.

House near El Paso, TX. Notice the 2,500 gallon poly-water tank (uses water well pump for water pressure).

A household filter and distiller are not acceptable or "approved" forms of water purification for Texas border colonias…Why not? They need to be NSF-certified systems. Any company/organization with an electric-free system like solar stills that are approved by the NSF may have a promising future in providing systems to colonia residents all along the Texas-Mexico border.

The word "colonia" has become a bad word, and so people who choose to live rurally, and live in a simpler lifestyle, are often grouped among the

poorest of the poor, even if they are wealthy. The same Texas (in particular) laws apply to them, including the ones that forbid these homeowners to access electricity (even if it is available—causing their living conditions and quality of life to worsen to disparaging levels) unless they have a water well or get water from an "approved" centralized water supply.

Impoverished border town grows from shacks into community
By Emanuella Grinberg, CNN
July 9, 2011 3:57 p.m. EDT
www.cnn.com/2011/US/07/05/texas.colonias/index.html
What started out as a hodgepodge of trailers, shacks and homes in various stages of construction are giving way to homes typical of a middle-class American suburb as Las Lomas slowly prospers.

Screenshot from CNN shows a nice home in a Texas border colonia area—one of many thousands subject to the same colonia laws

Colonias, like every other community on the planet, may start out small as I mentioned before, but eventually grow and transform; despite counties that parallel the border (including inland within the continental United States) or that are away from the Mexico border, at the "magical" 151st mile mark and beyond. I am speaking of areas where actual colonia-like homes (such as deep in the Appalachian mountains or other rural areas) abound, yet have no state colonia laws such as these that forbid the sale of their homes or access to electrification unless they have an "approved" water source.

If the problem is *truly* about clean drinking water then a distiller or household filtration system would suffice because it solves the problem for clean drinking water. It is not just immigrants that live in colonias; US citizens live there too. To reiterate, if it were *truly* about clean water and

healthy living conditions then permanent programs should be in place by now to help provide purification systems or other ways to improve quality of life for ALL of those in need.

I have heard it said many times, including by an elected ex-House of Representatives, Hydrologists/Engineers, Community Leaders, and so on that what is happening in Texas colonias is unconstitutional. Mark my word that some attorney(s) in the near future will be filthy rich on a contingency fee when they hire someone who is Spanish-speaking (I am not that person) to help organize the people for a class action lawsuit due to Texas legislators that have made laws that are not only illegal, but that seriously damage peoples' property values, plus forbid them access to electricity that they need for quality of life (based solely on having "city water" (they know is not available) or a "well" (that is also not feasible in many desert areas because they can cost $10,000 to drill deep enough, and many come up dry or have horribly saline unpotable water)).

The consequence to these laws is that people have had electricity and could not get it turned back on once turned off, so they were forced to abandon their homes or live in true third-world conditions. Is this not a crime?

Others have bought land, spent thousands developing it and getting septic tanks and house foundations put in, only to find out they could not get electric service even if they paid for it entirely out of pocket.

Yet other families have built their homes and lived comfortably for decades but have a change in employment so needed to sell their house to move, only to find out that the new owner of the home cannot legally get electric service, and only the original owner can get a waiver to get it back on (in their name, ONLY if they live there themselves, but by then it is too late—these waivers were non-existent until well after the first colonia laws were instituted).

Who is going to pay for all of these losses that Texas has caused? I have heard so many horror stories over the years. This does not include the special favors that have been given to 'pay off' legal suits that were basically won behind closed doors—by those with money—against the state (yes, I heard about this firsthand from someone who ran a business in far east El Paso, but do not ask me… do your research!). However, many if not most colonia residents are not aware of the laws, let alone their rights, nor

do they always have the money to fight in a court of law to regain their financial and other losses. They give up, or they live without any amenities whatsoever, in far worse conditions, because they have nowhere else to go or cannot afford to lose what they have already invested in their home. It sickens me to think about it.

The losses have occurred to so very many families across the entire Texas border, whether Mexican (realize the majority of people living in US-Mexico border colonias are Hispanic), Caucasian, or other ethnic background, or whether they are rich or poor or in between.

The laws discriminate against their location and whether there is city water, yet the state is not paying to bring them that city water either. Their goal is to “eliminate colonias”so they do not have to pay—to force them to move and reduce population in these areas (many of which include immigrants, whether legal or not, including legal citizens), and so without dense population numbers in these rural pockets the officials are now especially disinclined to ever substantiate the cost of bringing city water to these areas. Problem solved, right? It is like big brother being a bully and abusing rather than helping his little brothers and sisters.

Colonia dwellers are doomed no matter what, unless they stay put forever (with or without electricity), waiting another 20-30 or more years before city water might finally arrive. Colonia laws are causing extreme hardships in numerous irreparable ways. Yes, irreparable because it is not reversible. The damage has already been done. They live without clean water, and in some cases without electric service, and not by their own choice, but by force.

Yet solar distillers can help people now, even if only in some small way. Small blessings can be a Godsend, however. They work whether or not there is electricity or city water pressure available. It is a solution to the health problem the colonia laws have caused/worsened.

Almost ANY water source, including pilas or water storage tanks, could otherwise be purified a good number of ways, from a whole-house filtration system, to RO systems, to solar water pasteurization methods, solar water distillers, etc., so realize that the laws are not actually promoting health via water sanitation, but rather causing unnecessary hardships on families by worsening their living conditions.

My son Tyler and "Donald" (still recipient) near Hueco Tanks Historical State Park east of El Paso, TX. Note the two 5-gallon jugs sitting on the still, which Donald said were BOTH filled to the brim daily via this solar distiller (due to the hot desert days).

The Texas colonia laws are found in Subchapters B, C, and E of Chapter 232 of the Local Government Code. These laws were designed to eliminate colonias in similar ways that laws in the past were designed to disenfranchise or eliminate "races" of people, and have made the residents' homes practically unlivable (without access to electricity, although since then there is one law—HB 2096—that they passed that grandfathers in the original homeowner—since then other Senate Bills or House Bills may have been passed as well, but as of this writing the colonia laws still stand, much to Texas' own detriment in the end, I predict). The laws have devalued the homeowners' land substantially (making it worthless and unsellable). It is illegal for the homeowners/property owners to sell their own property, and all of this done without the reason of "imminent domain" by the state of Texas. *Houston, we have a problem* (or should I say Austin?).

Aside from a collective lawsuit, the only way around these laws for individual land owners is to make them not applicable to one's life… by living sustainably on their own property without the need for their centralized utilities and the bills that go with them. At least there is hope for a return to quality of life in this way for those who feel stuck. It should not

be illegal to *choose* to live off the grid any more than it is legal to be *forced* to live off-grid.

Perhaps for some there is no need for a *non-transferrable* Certificate of Compliance to receive electric service like anyone else in the city has the right/privilege to (colonia dwellers are not afforded the same rights/privileges, and in fact, have no rights as legal land owners now, so there is definite discrimination here).

Texas colonia laws? *We don't need no stinking Texas colonia laws!*

No electricity? Sure, because some people have solar panels and/or wind turbines, passive solar homes, and natural cooling systems like earthtubes.

No city water? No problem, because some people have rainwater harvesting, water storage tanks/cisterns, graywater recycling systems, NSF-approved composting toilets, and solar water distillers.

Yes, there are always ways to survive, and thrive, and live a healthy lifestyle, but who of the poorest of the poor in colonias can afford these things? It is a catch-22 and the state knows that, yet forces its heavy hand anyway.

The colonias are a worse mess than if the government had done something to help instead of hurt (hurt, in the name of "help") these families; but I digress… this is supposed to be about water and why solar stills are so crucial to humanity worldwide, not just in states or countries that do not take care of their people.

Solar still on top of a pila in west Texas colonia

This is exactly why solar water distillation is so important, because it is a method that is both inexpensive and reliable for bringing absolutely pure water to colonia dwellers, or anyone else for that matter. Solar distilled water is far cleaner than the chlorine-and/or-fluoride laden ‘approved’ city water that the rest of society drinks, which is full of a lot of other nasty smells and tastes and whatever else is in there and defined as ‘drinkable.’

I would probably apologize for the length of this particular portion of this chapter because it is a side-step to the actual construction of a solar distiller… but is it? Methinks that it is crucial for people to know, and for others to realize that people in the know, like me, need to be a call for help for the many silenced voices that have not been heard.

Here is an opportunity for you to help in colonias… where is the need? Fill it. Who has the deficiency? Aid them. Where is the money to do it? Go get it. Who can put a stop to this madness? Change it. Speak Spanish? Motivate the people, sign a petition, hire an attorney, do whatever it takes.

Still facing solar south with white shed wall behind it to reflect extra sunlight into the still to boost production

One last diatribe… I am not a conspiracy theorist, but realize that these laws were originally intended to go after shady land sales companies that promised water that would never come, yet somehow turned against the customers who bought the land in hopes of the so-called “American

dream.” Wake up America! I think it would be a good service to humanity to actually have laws that *serve* the people, rather than victimize the victims. Okay, I will get off my pedestal now about the laws that punish rather than advance individuals and families, including children and the elderly… that is all I have to say about that.

That said, it is no doubt true that in a number of the more poor areas in colonias some of the houses do not have adequate septic systems (if at all) and/or no running water. However, as we know, *not having city water <u>does not</u> equal not having potable water* and anyone telling you otherwise is ignorant of the truth. Solar water distillers are about as perfect of a solution as you can get for areas with full sun and a lack of utility services. The water is cleaner than mere “city water”… not just pure, but ULTRA-PURE by laboratory standards and testing. Distilled water is the purest water on the planet, period.

Grunge in the bottom of a 55 gallon drum (a water storage container found in some border colonias).

Whether people drink water out of a drum like the one shown above or not, it is simple solar water distillation technology will remove ALL non-volatile contaminants from non-potable water stored in containers such as particulates (salt, sand, sediments, rust, etc.) heavy metals, and other contaminants, and a small carbon filter will solve any problems with possible volatiles.

To recap, the solar stills are appropriate technology for colonias, rural, and other areas because they are site-specific, use no electricity to run, have a quick payback period, require no running water to work, get rid of all microbial contaminants (including giardia and coliform bacteria, which are commonly found in colonias and other areas), have a life expectancy of 20+ years, and are easy to use and maintain. They are especially great for people with health problems, the youth or elderly, or pregnant women.

SolAqua style stills installed
for a family in Anapra, Mexico

Now, with the tools I provide in this book, solar distillers can be made by colonia dwellers, and grants can be gotten by Universities, NGOs, non-profit organizations, church, and the like, to provide solar still materials/kits or manufactured distillers to these communities in need.

If nothing else, perhaps you can build a still yourself and teach someone else how to build one. Or perhaps you can buy them a copy of this book so they can build it themselves. Or if you are so inclined, you could give them the copy you hold in your hands or share it with someone else who can make a difference. How can you make a difference for someone today, or next month, or before the year is out? Writing this book, and providing version-1 of this book free to the public, is my personal contribution. I pray for a better society where people take care of each other, and where government does the same.

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Enjoy building and using your solar water distiller!

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